ANNUAL A.P.I. NUMBER

the OIL AND GAS JOURNAL

MILESTONES IN CAMERON PROGRESS

How things are "shaping up" at Cameron

In 1946 CAMERON IRON WORKS perfected the closed die method of press-forging relatively large and intricate steel shapes, thus extending the metallurgical advantages of forged steel beyond the realm of small and simple patterns.

Today, most CAMERON products are produced by this press-forging process, hence possess qualities of grain structure, homogeneity, and freedom from defects which cannot be produced by any other method.

The field for this unique steel-working process developed by CAMERON is unlimited — breech rings for heavy artillery — general industrial equipment — refining — wherever stresses are likely to cause mechanical failure.

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IRON WORKS, INC.
World Leader in Pressure Control

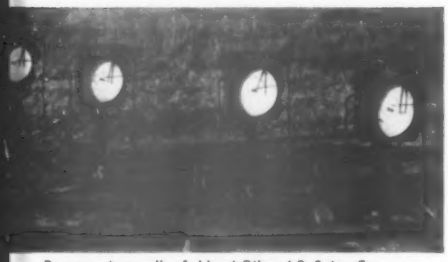
C. I. W., Inc., P. O. Box 1212, Houston, Texas. Export: 7912 Empire State Bldg., New York, N. Y.

Making a press-forging at Cameron

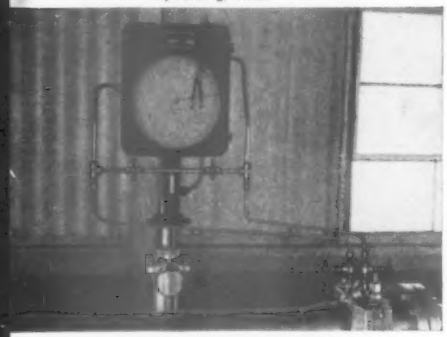
PRICE 50 CENTS TABLE OF CONTENTS ON PAGE 1 NOVEMBER 17, 1952

Gas booster station, Lion Oil Company, Scurry County, Texas

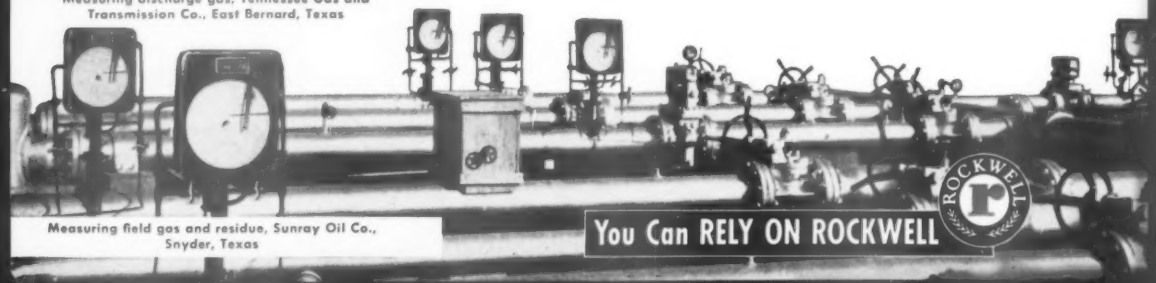
Wilshire Oil Company, Snyder, Texas



Repressuring wells, Ashland Oil and Refining Co., Spaulding, Okla.



Measuring discharge gas, Tennessee Gas and Transmission Co., East Bernard, Texas



Measuring field gas and residue, Sunray Oil Co., Snyder, Texas

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You see Rockwell orifice meters *everywhere* in the oil and gas industry. Instrument-accurate performance, low maintenance costs and service ease are the big reasons for the swing to Rockwell. It's all wrapped up in a better engineered design having a more accessible assembly with heavier parts of improved materials. Ask your Rockwell representative to demonstrate these advanced features, or write for Bulletin 1050.

Your operator can mechanically calculate up to 300 average charts a day on a Rockwell Integrator. She does it with machine precision by tracing the same static and differential lines that were left by the pens on the gauge. Accuracy within ½ of 1 per cent is practical. Full description in Bulletin 1016.

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THE OIL AND GAS
JOURNAL
Vol. 51, No. 28

CONTENTS FOR NOVEMBER 17, 1952

NEXT WEEK

- Journal report on Drilling and Producing Regulations of the Texas Railroad Commission.
- Socony-Vacuum Reconditions Line Over Ditch Without Interrupting Service.
- First Commercial Catforming Unit on Stream at McBride Refinery.
- Petrochem Report: Texas Eastman Co., Longview, Tex.
- Report on Use of Tubing and Casing as Drill Pipe.
- Geological Report: Gebo Field, Hot Springs County, Wyoming.
- Other articles and regular features.

REGULAR DEPARTMENTS

They Say	215
Calendar of Events	219
Journally Speaking	223
Editorial	225
This Week	227
Watching Washington	249
International News	252
Personals	254
Deaths in the Industry	256
Engineering Reference	419
Modern Drilling	421
Refiner's Notebook	423
Heat Transfer	425
Pipe-Line Construction	427
Pipe-Line News	439
Natural-Gas News	442
Natural-Gasoline News	442
Refining News	445
Drilling Contractors	448
Active Rotary Rigs	450
Exploration Statistics	474
Production Statistics	475
Refining Statistics	476
Market Statistics	477
Equipment Men in News	478
Classified Advertising	481
Advertisers' Index	484

EXPLORATION—DEVELOPMENT

Texas Sand Studies	453
Highlights of Week	453
Reports by Areas	454

NEWS FEATURES

Journal coverage of the 1952 Biggest-of-All A.P.I. Meeting	228-245
Synthetics Oils Said Highly Desirable for Special Lube Functions	246
Big Capital Outlay for Geophysics Imposes Heavy Responsibility	246
Thorough Seismic Testing Just Beginning in the Southeast	247
New I.P.E. Exhibition Area Added As Show Sells Out All Space	247
Court Cuts Number of Records Required in Oil "Cartel" Case	248
Government Passes Favorably on U. S. Pipe-Line Contract Plans	249
Petrochemical Output to Exceed 17 Billion Pounds This Year	250
Sinclair's Somali Rights Include 9-Year Exploration Concession	252
French Oil Company Strikes Oil in Northwestern Tunisia	253
Surprising Heavy Rush for Acreage Results Under Peru's New Law	253

ANNUAL A.P.I. SECTION

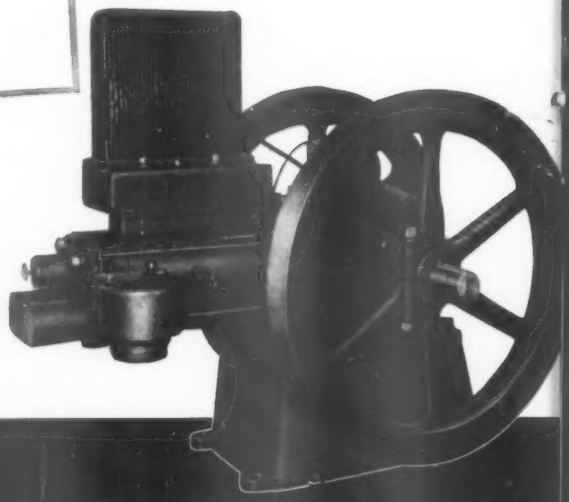
Higher Octane Numbers by Thermofor Cat Reforming	357
Microwave Control of Pump Station Raises Line Capacity at Minimum Cost	258
What's the Outlook for Oil-Country Tubular Goods?	262
Water-Imbibition Displacement . . . Can It Release Reluctant Spraberry Oil?	264
Evaporation Loss of Petroleum from Storage Tanks . . . A Symposium	266
How to Plan a Waste-Disposal Program in Urban Areas	296
The Williston Basin . . . Today's Newest, Most Exciting Oil Province	317
How to Train Supervisors	321
How the Industry Banks on Meeting Future Petroleum Demands	328
Stress Failure in Big-Inch Gas-Transmission Pipe	344
Thermodynamic Properties of Hydrocarbons and Related Compounds	352
Use of High-Speed Computing Machines—For Oil Production Problems	260
How to Prevent Failures in Sucker-Rod Joints	371
New-Type Drilling Mud Offers Some Interesting Advantages	380
Houdriforming . . . At Low Pressure	386
Natural Gas in an Expanding Economy	394
Gas Injection in Water-Flooding Operations	400

ENGINEERING-OPERATING FEATURES

Engineering Reference Section	419
Modern Drilling	421
Refiner's Notebook	423
Heat Transfer	425

For Oil Well Pumping

FAIRBANKS-MORSE
serves you best!



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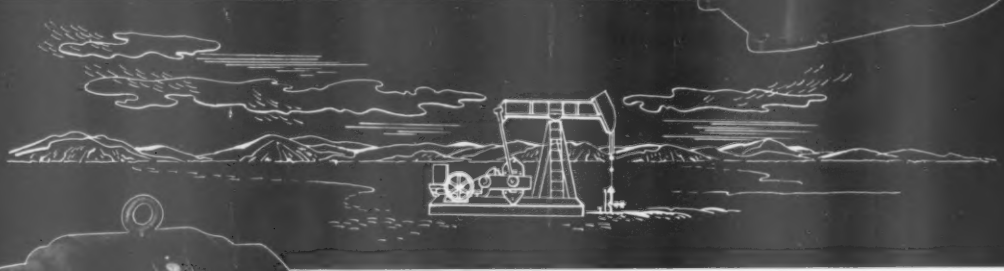
the famous Fairbanks-Morse "ZC" is your best choice for economical, efficient service. The big, *extra* heavy flywheels of the "ZC" assure considerable savings in gas or gasoline . . . protect engine and driven equipment against excessive wear. The simple, rugged, single-cylinder "ZC" design means easy maintenance . . . no complicated parts to cause trouble.



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the Fairbanks-Morse General Purpose Motor is your choice for stand-out . . . stand-up performance. Check the exclusive, indestructible "Copperspun Rotor" . . . unique cross-flow ventilation . . . protected, one-piece cast frame and it's easy to see why they are tops for the heavy starting loads and long-period, peak-capacity operation of oil field service.

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since Fairbanks-Morse manufactures both motors and engines, we are able to recommend, without prejudice, the exact power choice that will serve your pumping needs best. Fairbanks, Morse & Co., 600 S. Michigan Ave., Chicago 5, Ill.

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When you want reliable, low-cost pumping power

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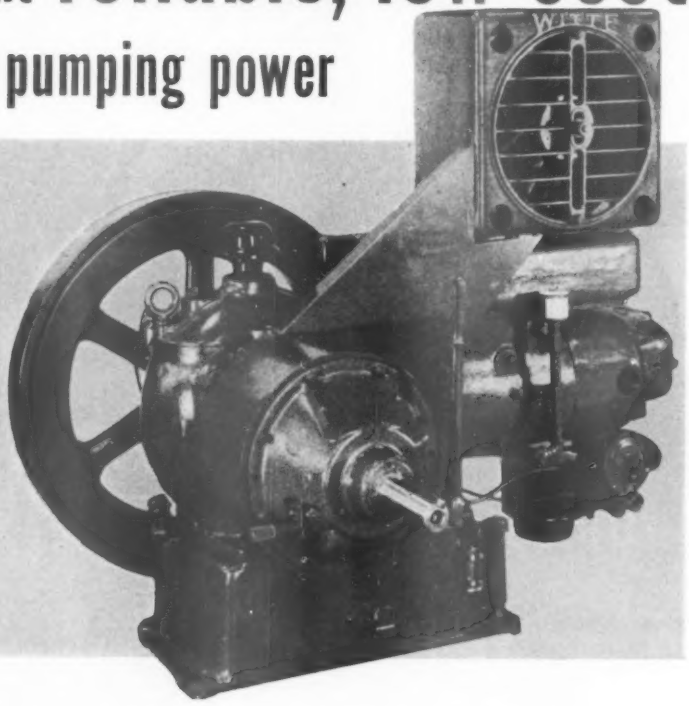

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These single-cylinder, gas-gasoline models are of the horizontal, water-cooled, slow-speed, four-cycle type and are equipped with condenser-type cooling system, removable wet cylinder liner and roller type main bearings. The Witte "B" and "C" engines have well-earned field reputations for top performance and long life.

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Gas-gasoline — Models from 5 to 15.5 hp.

Full diesel — Models from 3.75 to 12.5 hp.

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Ball and Roller Bearings keep company with America's hardest working equipment

● Oil country equipment gives bearings a tougher workout than any other service. Loads and speeds are often high and unpredictable, and bearings must work surrounded by vicious killers like abrasive dirt and dust, corrosive sour crudes, brine, drilling mud and cement slurries.

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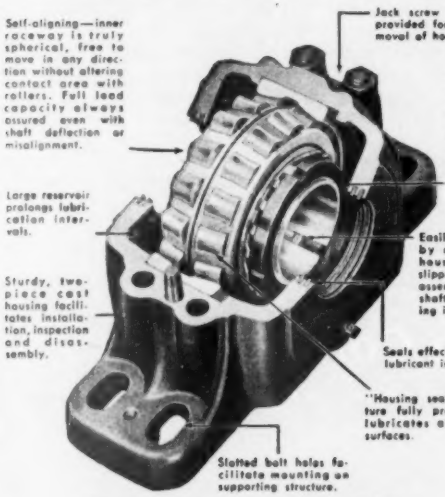
There are Link-Belt Bearings for the light jobs and the heavy ones. Let us help you apply Link-Belt Bearings to your equipment. Or call or write for Data Book 2550 for complete engineering details.

▲ Crutcher-Rolfs-Cummings Middle Incher Ditching Machine uses 14 Link-Belt Bearings on the tracks and shafts. This ditcher on a recent job ripped out a 6000 foot ditch in hard caliche and loose rock in a single 10-hour shift. The ditch was 42" wide and 5½ feet deep. The Middle Incher has averaged digging out 17 feet per minute on some jobs—that's 1360 cubic feet per minute!

CUTAWAY OF SERIES 6800-6900 TWO-PIECE ROLLER BEARING PILLOW BLOCK


Jack screw holes are provided for easy removal of housing cap.
Self-aligning—inner raceway is truly spherical, free to move in any direction without altering contact area with rollers. Full load capacity always assured even with shaft deflection or misalignment.
Tapered adapter sleeve provides positive concentric mounting on commercial shafting.
Large reservoir prolongs lubrication intervals.
Easily installed by removing housing cap, slipping adapter assembly onto shaft and locking in position.
Sturdy, two-piece cast housing facilitates installation, inspection and disassembly.
Seals effectively keep lubricant in, dirt out.
"Housing sealing" feature fully protects and lubricates all moving surfaces.
Slotted bolt holes facilitate mounting on supporting structure.

One of many types in the Link-Belt line of Pillow Blocks, Flanged, Flanged Cartridge, Cartridge, Hanger, Take-Up Blocks and Unmounted Bearings.

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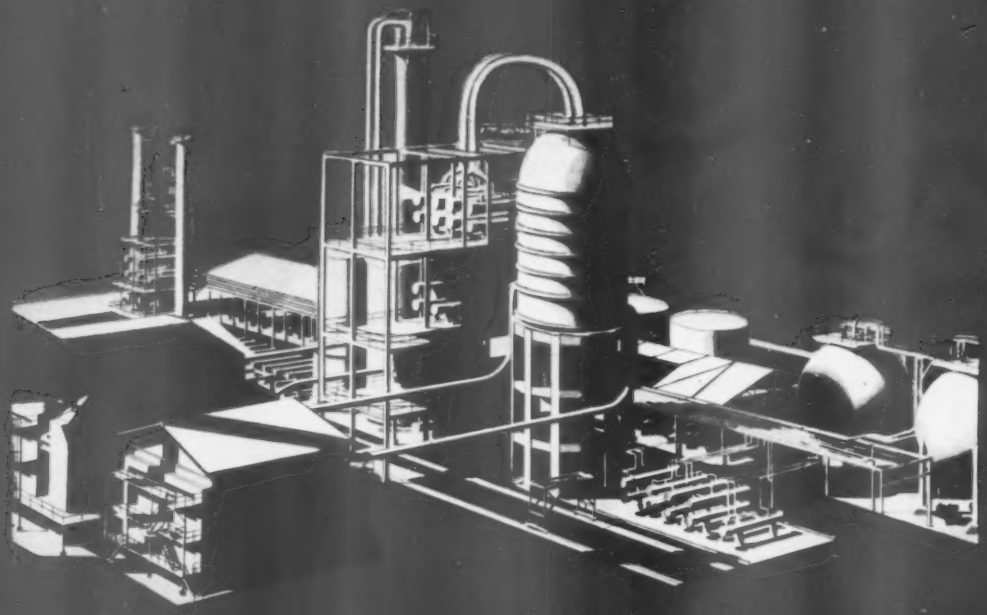
crude distillation units



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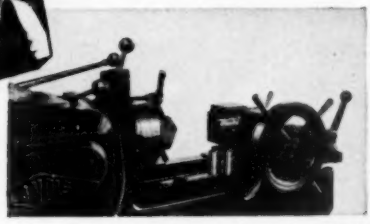
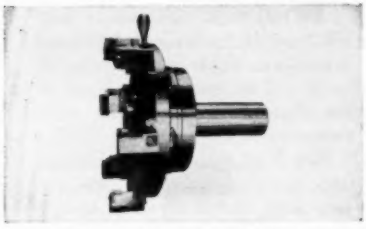
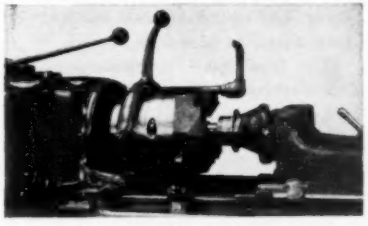
- Product Design
- Process Development
- All Types of Threading Equipment
- Special Applications



A 1½" Single LANDMACO Machine equipped with special work holding fixture for threading adapter sleeves.



A Special Die Head (LANDMATIC 40AXX) designed and built to thread valve seat rings up to diameters of 14¾".



A 1½" Single LANDMACO Machine equipped with special carriage front for threading axle housings.

New and improved products often create unprecedented threading problems—both in design and production. Realizing this, we offer all manufacturers the help of our Thread Engineering Service in efficiently and economically solving their Thread Problems.

The difficulty may be in designing a thread which will function properly as an operating part, or in producing a thread already designed. Whatever the problem our Engineering Department is ready to help with advice and assistance—or to undertake the solution alone.

After examining all phases of the problem, the necessary recommendations will be made on basic Thread Design, the production process, and the Threading Equipment that should be used. For example, often a difficult Thread Production problem can be solved with a slight change in basic Thread Design. Occasionally, a job is so unique that special equipment is needed —three such Special Equipment Applications developed by our Engineering Department are illustrated.

Whatever your Thread Problem, use our THREAD ENGINEERING SERVICE. Hundreds of manufacturers have been able to perform difficult threading operations efficiently and economically with Landis Threading Equipment. The years of Thread Experience and Engineering Know-How that has brought LANDIS to the fore in Thread Generating is at your service. May we help you?

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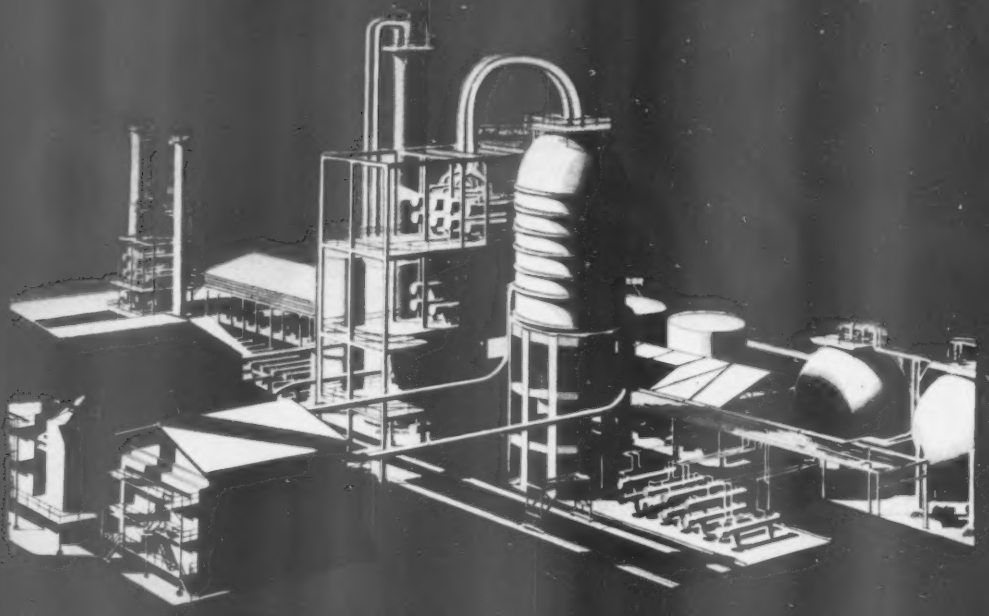
crude distillation units



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- All Types of Threading Equipment
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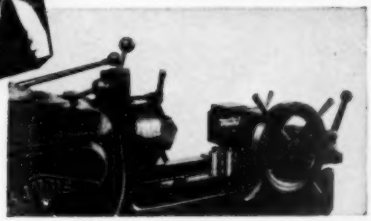

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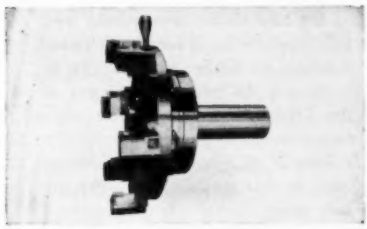

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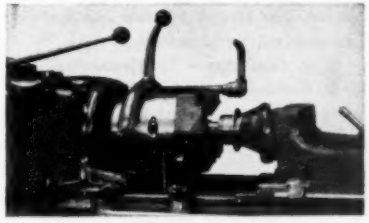

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While Bethlehem makes and will gladly furnish rotary tables for drawworks hook-up, we'd like to point out the many advantages of the Hydrodrive rotary unit with independent engine.

First of all, what does Bethlehem offer in this respect? We offer the two most commonly-used sizes—21-in. and 17½-in., *both standard tables.* Either is available with gas or diesel engine and torque-converter drive. The system has two forward transmission ratios, one reverse.

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Bethlehem Hydrodrive tables can be used at floor level or underneath the floor, whichever you prefer. And there are other features, too, that you'll want to investigate—because they mean an easier type of drilling. For full details, call or write the nearest Bethlehem Supply office.

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with GUIBERSON GW CUPS

Save time . . save money . . save *fluid* . . with GW cups . . with K Swabs — products of Guiberson's more than one third century experience serving the oil industry

GW Cups Assembled on famous Guiberson K Swab

If you want to *swab*—not just agitate—flexible Guiberson GW cups on the Type K Swab will pull every drop. They hug the casing wall — provide automatic seal and controlled pipe contact — pull a vacuum and clean the well!

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THE

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Sold By Leading Oil Field Supply Stores Everywhere

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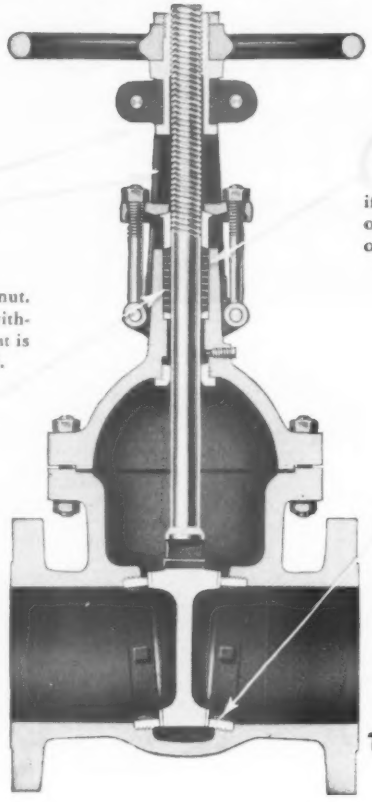
OIC BUILDS FROM THAT POINT UP

LOOK AT THESE FOUR FEATURES:



1 2-PIECE YOKE DESIGN
simplifies replacement of yoke nut. Permits replacement of yoke nut without shutting down the line. Yoke nut is OIC Alloy 40; non-galling material.

2 STUFFING BOXES
have greater depth than is specified, permitting the use of 7 to 9 rings of packing, with either wiper rings or condensing chamber below.

3 OIC'S SEAL-EVER PACKING
(exclusive with OIC) lasts 10 to 15 times longer than ordinary packing. It stops pitting and corrosion of stems.

4 SEAT RINGS
are end-seated and are subjected only to compression forces when valve is closed; no loosening of seat rings with repeated opening and closing of the valve. No open spaces to cause turbulence, accumulate dirt and hasten corrosion.

THE BEST STEEL VALVE YOU CAN BUY

This combination involving yoke design, stuffing boxes, packing and seat rings is evidence of OIC's desire to build *beyond* minimum specifications.

THE OHIO INJECTOR COMPANY, WADSWORTH, OHIO

OIC FOUNDED 1883

VALVES

FORGED AND CAST STEEL · IRON · BRONZE

Something you may not have noticed about the S.S. United States

You've probably read all about the amazing construction, the great size and the record-breaking speed of the liner United States.

But you may not have noticed something extremely important about her crew. Every officer or man in a post of responsibility is a man of impressive experience. Her present skipper has been a ship master for thirty-two years. The chief engineer has been in engine rooms for 29 years. Even her executive chef has been in charge of ships' kitchens for 25 years.

In an operation as complex as sailing a great liner . . . or serving a great industry . . . there is simply no substitute for experience. And it is interesting to note that most of the men at the helm of the company which supplies the petroleum industry with the major part of its antiknock compound requirements are men who have been with Ethyl for upwards of twenty years.

(Continued on next page)

ETHYL
ETHYL CORPORATION

Printed in U. S. A.

Something you may not have noticed about the S.S. United States

(Continued from preceding page)

For example: The man in charge of manufacturing at Ethyl has been with us for 26 years. The head of technical services has had 23 years of Ethyl experience; the vice-president in charge of sales started with Ethyl 26 years ago; and all four regional sales managers have more than twenty-two years of service.

Is it any wonder that Ethyl appreciates and understands the problems of refining, distributing and selling petroleum products? So, whether the going is rough or smooth—and the oil industry has gone through plenty of stormy weather—you can rely on experienced Ethyl people to be on deck when you need them.

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Ethyl service is backed by 29 years of antiknock experience

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TECHNICAL REPORTS

SALES HELPS

ROAD TESTING

GASOLINE TESTING

a "Natural"!

VERTICAL FIRING
with
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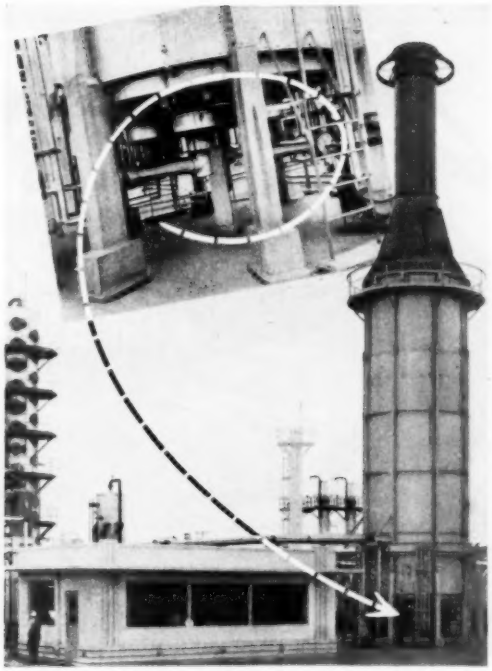
oil-gas up-fired
TANDEM COMBUSTION UNITS*



A large up-fired petroleum heater, in a modern Texas refinery, equipped with National Airoil combination gas and oil Tandem Block Combustion Units, for firing upward. This installation is one of many throughout the U. S. and other countries so equipped with our exclusive Tandem Units.

means

many, many additional hours "on stream" for your petroleum heaters!

HERE'S WHY . . . because NATIONAL AIROIL Tandem Block Units are *more* than just combustion equipment. They are an *exclusive* up-firing *Combustion System* which has *proved* many more hours "on stream" without shutdown. "Airocool" Tandem Combustion Units (firing dirty refinery gas; uncut asphalt; refinery fuel oils) hold air in the combustion zone until fuel and hot air are mixed thoroughly. This means that combustion takes place in a hot zone; the result . . . increased combustion efficiency with a minimum of excess air.

NATIONAL AIROIL's patented system of tandem combustion blocks allows secondary air to be controlled easily and accurately . . . and flame can be adjusted to radiate heat uniformly to the tubes without *impingement*.

The Tandem Unit is popularly fired with NATIONAL AIROIL Combination Oil and Gas Burners . . . has a high turn-down ratio with a steady flame . . . maintains high flame temperature with either fuel oil or gas; and can be brought quickly to full capacity with a clean fire.

You will realize higher profits from YOUR heaters when Tandem Combustion Units are specified.

*PATENTED NOV. 1943, DEC. 1944—JUNE 1950.

CHEMICAL-PETROLEUM DIVISION

NATIONAL AIROIL BURNER CO., INC.

***Main Office & Factory:* 1236 EAST SEDGLEY AVENUE, PHILADELPHIA 34, PA.**
Southwestern Division: 2512 South Boulevard, Houston 6, Texas
INDUSTRIAL OIL BURNERS, GAS BURNERS, FURNACE EQUIPMENT

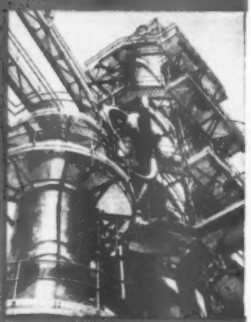
Specify KLEMP

✓ Grating and Stair Treads for Greater Safety

✓ Ganister Lining Reinforcement Meshes for Longer Life

(Above) Thousands of square feet of KLEMP HEXTEEL installed in World's Biggest Catalytic Cracker Unit at this Giant Gulf Oil Refinery in Port Arthur, Texas.

(Below) DIAMOND RIVETED GRATING serves for strong, clean, non-slip, fireproof, ventilated catwalks, mezzanines, stairways and platforms, prefabricated to your most exacting specification. Shown here is a Shell Oil Company installation.



(Above) GANISTER LINING REINFORCED with KLEMP HEXTEEL (shown being welded into a rat cracker) keeps CATALYST REGENERATORS ON LINE Longer. HEXTEEL, when applied as a reinforcement mesh is filled with a cement filler. This reduces "turnarounds" to a minimum and helps avoid scouring and abrasive actions of the catalyst which can quickly ruin rat crackers and thermal crackers.

We Tread the World with Safety

The Klemp Metal Grating Corporation has been serving the needs of the Oil Companies for almost Half A Century. During this time Klemp has produced and patented several specialized gratings, such as HEXTEEL® and FLOORSTEEL® reinforcement meshes for use in fractionating vessels for the Oil, Chemical and Petro-Chemical industries.

KLEMP DIAMOND RIVETED and KLEMP KREST WELDED GRATINGS are consistently specified for stair treads, walkways, landings, tower stairs, catwalks, stairways and many other applications.

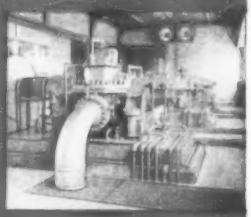
We are the only grating company to do all of our own work and we have complete fabricating facilities from complicated radial "set-ups", down to simple runs. Our engineers have spent a lifetime in this business and their specialized experience is at your service. We solicit the opportunity to solve your most difficult grating problems.

Write for Klemp's two new, free, fully illustrated technical catalogs, titled—

KLEMP 4 "Grates" serving the Nation's Major Oil Companies

KLEMP Open Steel Grating And Stair Treads

(Below) HEW KLEMP KREST® WELDED GRATINGS are made from special steel bars so formed to provide a pock or krest on the top side of the bar which gives this type of grating maximum non-slip characteristics. Ideal for structural foot walks as well as all other universal uses.



(Above) KLEMP FLOORSTEEL, because of its greater flexibility, is used to line the pipes leading to and from the catalyst regenerator. FLOORSTEEL is ideal for slimmer stack units and also protects the narrow throat of the catalyst regenerator.

(Below) Klemp Manufactures Diamond Riveted, Welded and Serrated Stair Treads. This Serrated Tread has been developed especially for installations where unusual precautions are necessary to avoid accidents resulting from grease, mud, snow, etc.

Mr. Louis R. Turbeville
Consolidated Sales Agency
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KLEMP METAL GRATING CORPORATION

TOPS

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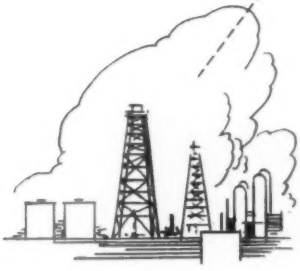

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ANSWER

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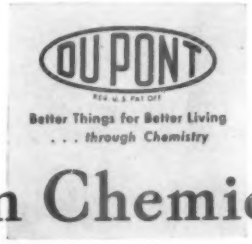
And, from 1923 to September 1945, Du Pont was the sole user of this method and the only manufacturer of TEL in the United States.

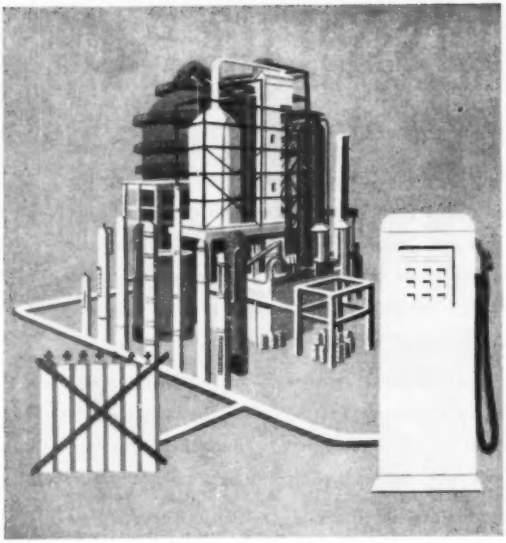
Today, wherever tetraethyl lead is made, the basic principles developed by Du Pont are still in use. But, in Du Pont plants only, a new and better method will soon be introduced. This too is exclusively a development of Du Pont's experience and research.

The many Du Pont services available to refiners, like its manufacturing facilities, are based on 150 years of continuous research and sound business practice. That's why more and more refiners are calling on Du Pont for technical advice and research assistance as well as marketing help and other services.



Petroleum Chemicals

E. I. DU PONT DE NEMOURS & CO., (INC.) • Petroleum Chemicals Division, Wilmington 98, Delaware



Sell Butane at Gasoline Price

THE VAPOR PRESSURE OF CATALYTICALLY CRACKED GASOLINE CAN BE AN IMPORTANT REVENUE FACTOR. TABULATED BELOW ARE TYPICAL FIGURES SHOWING THAT AT NORMAL CATALYTIC CRACKING YIELDS, FILTROL'S NATURAL CATALYST (GRADE 58) WILL PERMIT THE INCLUSION OF TWICE AS MUCH BUTANE AS OTHER CATALYSTS IN GENERAL USE. THIS REPRESENTS ABOUT $700 PER DAY ADVANTAGE FOR FILTROL CATALYST, EXCLUSIVE OF OTHER ADVANTAGES.

	FILTROL* CATALYST FLUID 58	OTHER CATALYSTS
FEED B/D	10,000	10,000
GASOLINE (C5-420°F)B/D.	4,800	4,400
RVP	5.0	6.8
OCTANE NO. F-1 CLEAR	90.0	91.6
OCTANE NO. F-1 + 3cc TEL	96.0	96.8
R.V.P. OF PRESSURED GASOLINE	10.0	10.0
B/D nC_4 REQUIRED FOR PRESSURING	500	250
TOTAL B/D 10# GASOLINE	5,300	4,650
DOLLAR ADVANTAGE	$700/D	BUTANE SAVINGS ALONE

(Basis 7c/gal. differential in sale price between n-butane and gasoline)

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FIRST
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Fast moves chop off non-profit time — and mobile Bucyrus-Erie spudders are right at the head of the pack when it comes to quick location-to-location jumps. With these dual pneumatic semi-trailer or tandem axle units, you can transport spudder and working tools in a single compact unit — at normal highway speeds.

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The practical way to save pipes, tanks, derricks, buildings, pumps, roofs, fences

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May be applied directly over rusted surfaces without removing all the rust!

RUST-OLEUM is the *practical, sensible* answer to your rust problems. Cuts your maintenance costs, because it may be applied *directly over rusted surfaces* after wirebrushing and scraping with sharp scrapers to remove rust scale and loose particles . . . costly sandblasting and chemical pre-cleaning are not usually required. This often enables *one man* to do the work of two with RUST-OLEUM! Practical, too . . . because RUST-OLEUM beautifies as it protects in *all colors, aluminum,* and *white.*

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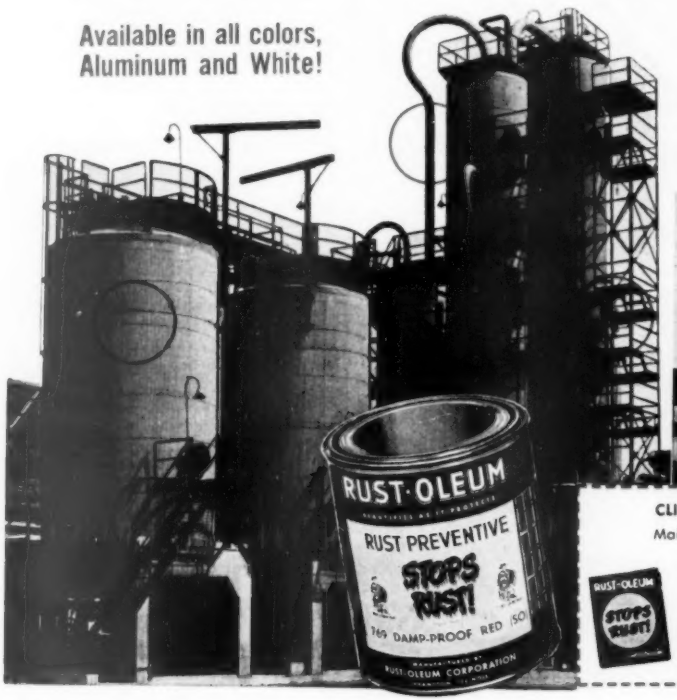
Available in all colors, Aluminum and White!



Dries to a tough, elastic coating that resists fumes, moisture, heat, weathering, most acids and chemical dusts

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Edward Fig. 444-448 series, built in sizes ¼ to 2 in. inclusive . . . forged steel globe and angle . . . 600 and 1500 lb sp . . . bolted or union bonnet . . . screwed or socket welding ends . . . Fig. 448 illustrated.

CHECK THESE Big FEATURES

- ✓ Hard bronze yoke bushing to prevent stem seizing or galling . . . lock welded to yoke
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- ✓ Tight, easily accessible bolted or union bonnet joint . . . with Ironkote gasket of 90 Brinnel max. hardness for leak-proof joint
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Please send literature covering your Fig. 444-8 series all-purpose forged steel valves.

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Subsidiary of ROCKWELL MANUFACTURING COMPANY

EAST CHICAGO, INDIANA

MADE TO MEASURE FOUR MILES DOWN—

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HALLIBURTON'S

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extra heavy duty

MEASURING DEVICE

Equipment measuring the deep wells has to be built for the job. Halliburton's Extra Heavy Duty Reel and Assembly is precision engineered for accurate measuring at depths of 15,000′ to 24,000′.

It's made of steel and cadmium plated, equipped with sealed ball bearings, precision built Twin Disc positive but gradual action clutch; specially designed hand brakes with inner and outer brake shoes on brake drum allowing sufficient exposure to air for fast dissipation of heat; maximum braking effect with sensitivity and accurate control. Capacity approx. 24,000′ .066″, 20,000′ .072″, 17,000′ .082″, and 15,000′ .092″ diameter line. Suitable for hand or power operation.

This Extra Heavy Duty Measuring Device joins Halliburton's complete line of measuring equipment that has been recognized for 25 years as the most dependable and accurate in the industry. Other improvements and developments include new Measuring Line Wipers, Latch Type Hay Pulleys, and Stuffing Box and Staff Assemblies.

Regardless of the depth or use involved, there's a Halliburton Measuring Device built for your needs . . . Phone your nearby Halliburton representative for the best in measuring accuracy and for maintenance service that protects your investment. Halliburton Oil Well Cementing Co., Duncan, Oklahoma.

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YEARS AHEAD IN MEASURING ACCURACY

A man with a hate

● There's no halfway feeling about fire and its resulting destruction with an expert fire protection engineer... he actually hates to see a little fire roar into a raging inferno and create a sizeable loss.

This personal sense of responsibility is inherent with C-O-TWO Fire Protection Engineers... a definite plus in your behalf. Whether its fire detecting or fire extinguishing ... portables or built-in systems... C-O-TWO means top quality backed by experienced engineering that results in operating superiority for you at all times.

With C-O-TWO Fire Protection Equipment, simplicity, practicability, longevity and minimum maintenance are built-in features that guarantee fast, positive action the instant fire strikes. Furthermore, extensive manufacturing and field installation skills, together with approvals such as the Underwriters' Laboratories, Inc., Factory Mutual Laboratories, Armed Forces and Government Bureaus assure you of the finest in modern fire protection equipment.

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This emblem Ⓐ on pumps, pump parts, accessories, and sucker rods is your guarantee of quality. As to service — NEVER JUNK AN AXELSON PUMP. We can make it as good as new in our near-by Pump Repair Shop.

AXELSON

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Guards Against Water, Oil and Pipe Scale

1. MECHANICAL SEPARATION

Deflector cup directs flow of air or gas together with water, oil and dirt to the walls of the housing and then downward at high velocity into the base where liquid and heavier dirt particles are deposited.

2. FILTRATION

Air or gas, having been mechanically cleaned, rises at low velocity through the Radial Finned Filtering element or insert which removes the lighter air-borne material.

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PIPE LINE FILTER

This exclusive Double-Action principle of Staynew Pipe Line Filters assures sustained, trouble-free operation. Inexpensive, quickly installed and easily maintained, these filters keep air operated or controlled equipment free from pipe scale, dust, dirt, and condensate. Wherever you require air and other gases *clean* and *dry*—demand and get—Staynew Pipe Line Filters.

Write today for complete Staynew Pipe Line Filter Bulletin B-1A.

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ALL TYPES OF FILTERS FOR EVERY INDUSTRIAL NEED

24 ACRES *Cover the World*

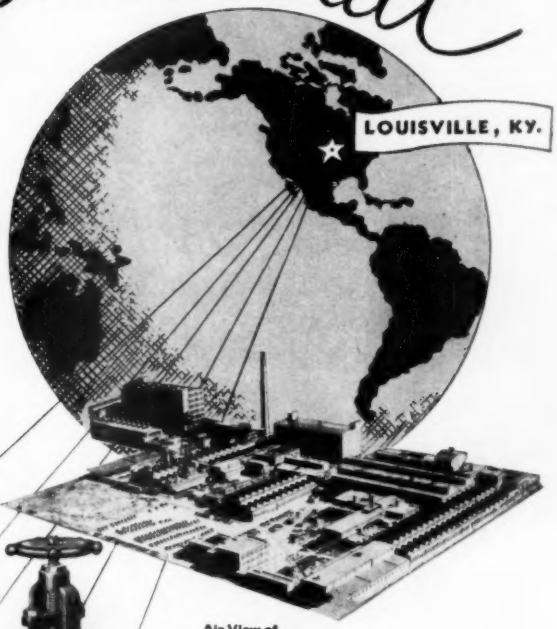
. . . with TOP QUALITY

DROP FORGED STEEL

VALVES, FITTINGS and FLANGES

by

Vogt



Air View of
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This 24 acre Vogt plant supplies the most comprehensive line of top quality *drop forged* steel piping materials anywhere available to industry. That's why they're the choice of leading refineries, power plants, chemical plants, etc., the world around!

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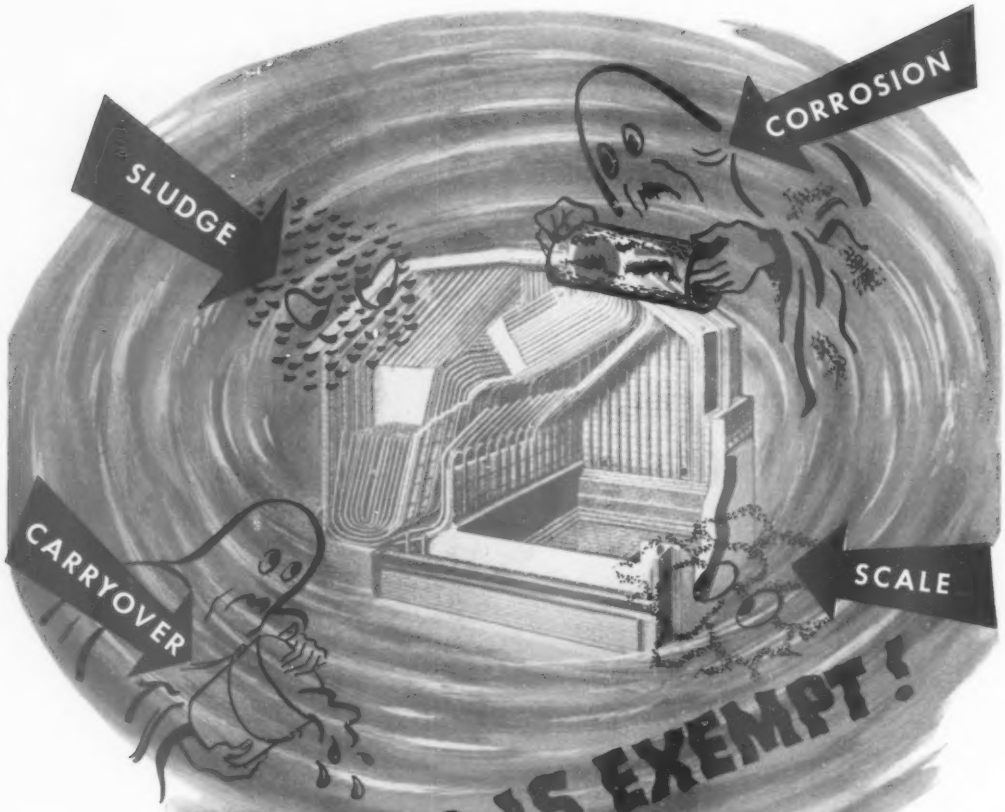

NO BOILER IS EXEMPT!

That's why we say "draw a bead on boiler sludge, scale, corrosion and carryover"

Tube failure, expense and inconvenience . . . even plant shut down await those who ignore these potential difficulties in their boiler operations.

Call in the Drew Engineer for thorough investigation, specific recommendations, proper treatment and frequent follow-up service that will clear up your boiler troubles or stop them before they start.

Write for the new booklet "Drew Boiler Water Treatment" describing methods used in overcoming boiler water problems.

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Service throughout the United States, Canada and South America

DREW PRODUCTS

You Spent at least $6,000 to create his job... will you spend $2.30 to Protect it?

Eye Accidents Cost $176,000,000 a year in LOST MAN-HOURS alone*

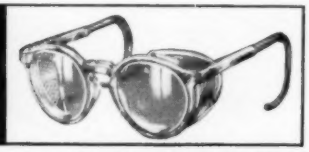
To give a skilled worker the tools and machines to produce, industry invests $6,000 or more per job. If you lose his skill due to an industrial eye accident, you tie up your $6,000 completely if he has no adequate substitute. You lose the production his tools turn out. And if his is a critical "bottleneck" operation, you may tie up entire plant output.

Even a production *slowdown* is grim business in these days of high break even points. Why risk it because of a costly eye accident, when the average cost of a pair of safety goggles that can prevent his eye accident is only $2.30? Call your nearest AO Branch Office and learn how an AO Eye Protection Program can save money well into four figures annually.

*Estimate. Industrial eye injuries cost over $5 per employed worker per year—with compensation averaging nearly $400 per injured man.

American Optical COMPANY

SAFETY PRODUCTS DIVISION

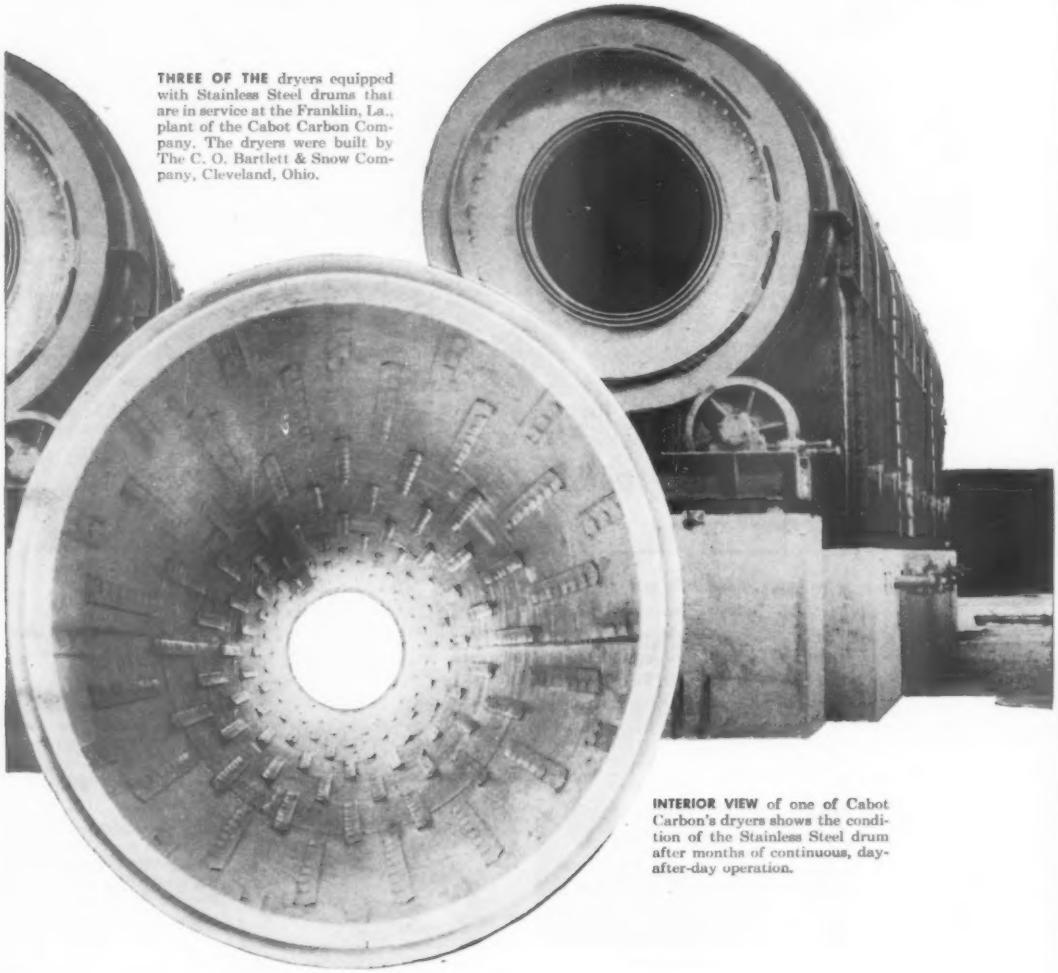


Write American Optical Company, 445 Vision Park, for free booklet "Improved Industrial Vision" telling how AO's Industrial Vision Program cuts costs, increases production, decreases accidents.

SOUTHBRIDGE, MASSACHUSETTS

BRANCHES IN PRINCIPAL CITIES

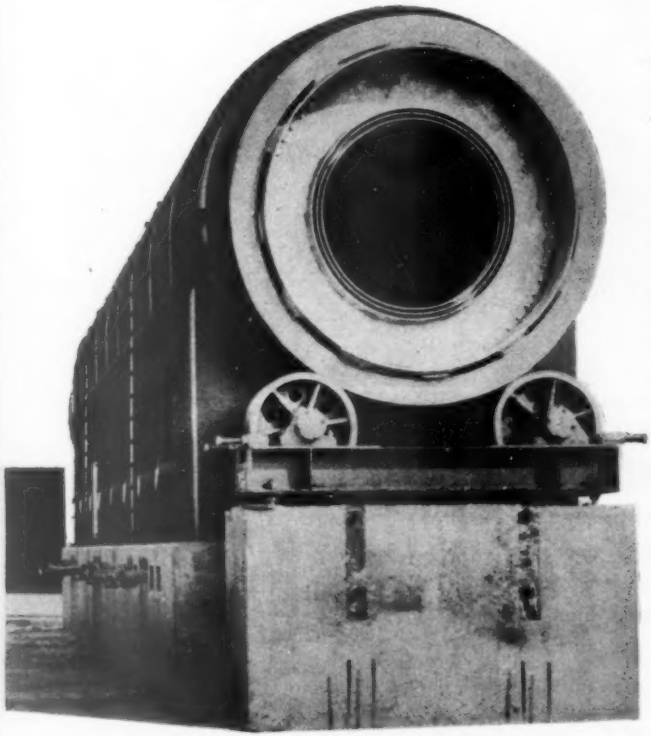
Only Stainless Steel passes the tests of and heat in these carbon



THREE OF THE dryers equipped with Stainless Steel drums that are in service at the Franklin, La., plant of the Cabot Carbon Company. The dryers were built by The C. O. Bartlett & Snow Company, Cleveland, Ohio.

INTERIOR VIEW of one of Cabot Carbon's dryers shows the condition of the Stainless Steel drum after months of continuous, day-after-day operation.

corrosion black dryers



• Round-the-clock processing operations put equipment to severe tests. Extremely corrosive materials are usually encountered and high temperatures are often present. That's why the choice of materials of construction is so often limited to just one—Stainless Steel.

Cabot Carbon Company, the largest operating subsidiary of Godfrey L. Cabot, Inc., of Boston, Mass., has a typical problem at its new plant at Franklin, La. The carbon black, when first made, is in dry fluffy form. In order to raise the density by pelletization, it is agitated with water and then run through dryers of Stainless Steel to remove the water and leave a dry, pelleted product.

The mixture of water with carbon black is too corrosive to handle in ordinary drums. And operating temperatures sometimes reach 1100°F. As a result, says Charles G. Allmon of the Company, "We have never used anything except Stainless Steel drums in these dryers."

Four dryers at the Ville Platte, La., plant of Cabot Carbon Company, have been in operation continuously for over three years, and another subsidiary of Godfrey L. Cabot, Inc., has used Stainless dryers for more than 15 years with no reported failures.

There are many applications in the petroleum and petrochemical industries where operating conditions make Stainless Steel equipment a must. Stainless Steel's combination of strength and corrosion resistance assure long life, minimum maintenance and freedom from costly down time.

And when you order Stainless equipment, specify U·S·S Stainless Steel. This perfected, service-tested material will give you the finest performance obtainable. Our representative will be glad to assist you in selection and application of the proper grade for the job.

UNITED STATES STEEL COMPANY, PITTSBURGH • AMERICAN STEEL & WIRE DIVISION, CLEVELAND • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
NATIONAL TUBE DIVISION, PITTSBURGH • TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. • UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
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U·S·S STAINLESS STEEL

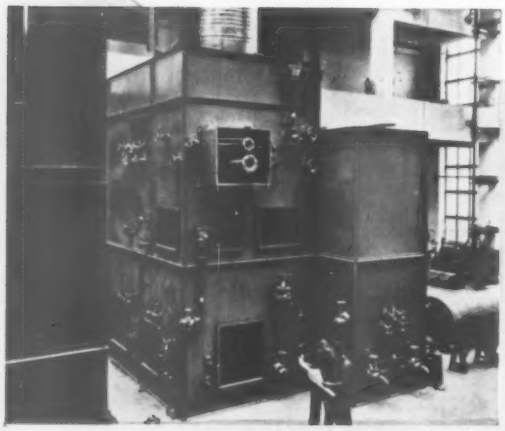
USS

SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

2-6976

UNITED STATES STEEL

BLAW-KNOX offers tonnage oxygen plants to increase your profits!



A typical Linde-Fraenkl Plant under construction

If you use or sell 10 or more tons of oxygen per day, get the facts and figures on Linde-Fraenkl Process plants now. Chemical Plants Division is experienced in the design, engineering, construction and equipping of units employing this highly efficient process. More than 100 plants are in continuous operation. The investment and operating costs are low. Our engineers will be pleased to discuss the many advantages of producing your own oxygen.

MORE AND MORE OXYGEN USED FOR:

Production of hydrogen from natural gas; of steel in Bessemer and Thomas converters; open hearth and blast furnaces . . . Gasification of coal for the synthesis of ammonia and high BTU gases . . . Production of hydrocarbons.

BLAW-KNOX
CONSTRUCTION COMPANY
CHEMICAL PLANTS DIVISION
930 Duquesne Way, Pittsburgh 22, Pa.

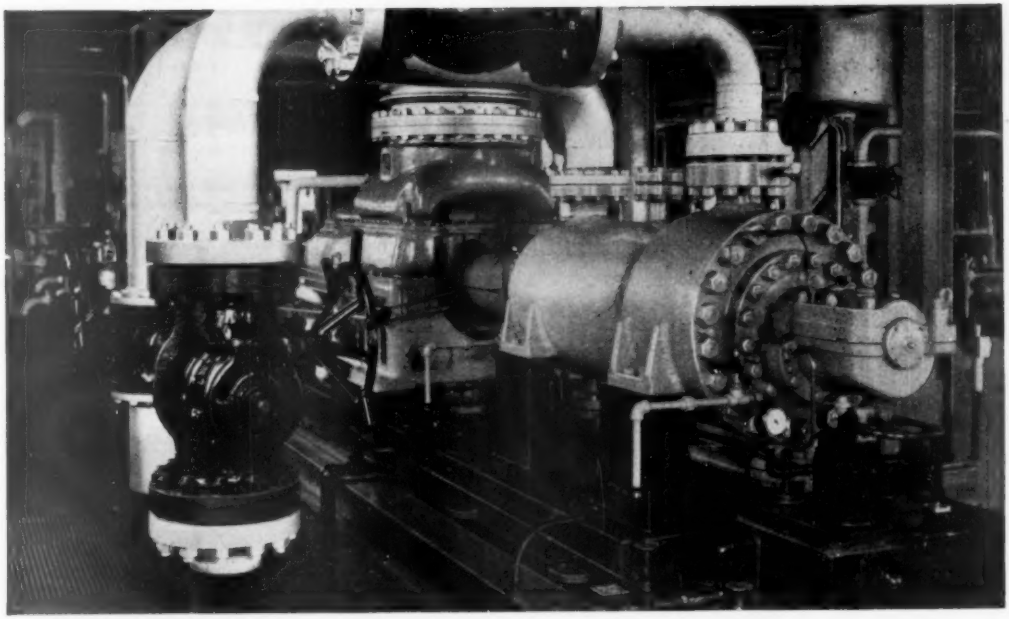
TULSA 1 • NEW YORK 17 • PHILADELPHIA 3 • CHICAGO 1
BIRMINGHAM 3 • WASHINGTON 5, D.C. • SAN FRANCISCO 5

HERE'S COMPLETE DATA. WRITE TODAY ON YOUR LETTERHEAD FOR THIS BULLETIN.

Ingersoll-Rand High-Pressure Pumps at the Katy Cycling Plant

SET IMPRESSIVE RECORD

of Maintenance-Free Operation



1943
1944
1945
1946
1947
1948
1949
1950
1951
1952

9 years without opening!

Two nine-stage CHT pumps were put into service at the Katy Cycling Plant in July 1943. These five-inch, double-case units, one of which is shown above, take lean oil at about 90°F. and 70 psi from the still after coolers and discharge it to the absorbers at 1850 psi. Throughout this entire nine year period, the pump casings have not been opened. The original bearing linings are still in service and the only maintenance required has been the renewal of inboard shaft sleeves and infrequent repacking. A third I-R pump of the same design, installed in 1944, has required no repairs to date.

This outstanding performance record is a typical example of the *extra dependability* that's built into every Ingersoll-Rand pump. Each unit is designed for real, long range economy that pays off in lower operating and maintenance costs year after year. If you have a pumping problem, your nearest I-R representative will be glad to help you.

Ingersoll-Rand

Cameron Pump Division
11 Broadway, New York 4, N. Y.

779-10

COMPRESSORS • DIESEL & GAS ENGINES • PUMPS • AIR & ELECTRIC TOOLS • CONDENSERS • VACUUM EQUIPMENT • ROCK DRILLS

This completely Bonderized® enclosure, more than a match for the severest weather conditions, houses:

1. Life-Linestarter . . . provides dependable control and accurate overload protection.
2. AB Circuit Breaker . . . assures positive, tamper-proof circuit protection.
3. Lightning arrester . . . protects both starter and pumping motor.
4. Time switch . . . converts control to automatic operation for cycle pumping.

This rugged Life-Line motor, power-packed for the toughest jobs, has:

1. Steel frame, bracket and feet . . . withstand the many severe shocks imposed on pumping operations.
2. Pre-lubricated bearings . . . need no further lubrication. Eliminate bearing failure from faulty lubrication.
3. Dynamically balanced rotor . . . assures maximum freedom from vibration. Gives quiet operation.
4. "Pear-shaped" lamination slots . . . allow coils to be slipped in place tightly without forcing. Leave no unfilled spaces to gather dirt.

WHAT *Life-Lines* REALLY DELIVER IS MORE SERVICE . . . LESS SERVICING

Whatever the weather... Wherever the job

this pair assures pumping efficiency

Weather offers no challenge to the efficiency of Westinghouse Oil Well Pumping Motors and Controls. Specially designed for outdoor pumping service, they shrug off attacks of snow, rain, dust and dirt. Life-Line motors have an outer hood which gives extra weather protection at less cost than totally-enclosed types. And the controls—AB Circuit Breaker and Life-Linestarter—are combined in one rugged, weatherproof, lightning-protected enclosure suitable for pole mounting.

What's more, this protected pair has the stamina to stand up under the demands of continuous pumping duty. They require minimum attention.

The Life-Linestarter provides accurate overload protection. It's advanced in design. Has only one moving element. Nothing to stick or jam. No chance of false operation from vibrations, jars or accidental blows. Where cycle pumping is required, the built-in switch handles the "ON" and "OFF" operations automatically. Means the pumper's periodic trips to the well for manual switching become a thing of the past.

As for the rugged Life-Line motor, it's made to take it! Has steel frame, bracket and feet that can stand the severe service encountered in oil well pumping. Pre-lubricated motor bearings need no lubrication . . . eliminate down time.

Assign this Westinghouse pair to your pumping operation. Gain the dependable service they deliver! Your Westinghouse representative will gladly give you a copy of the "Petroleum Book", B-5444. Or you may write, Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-21714

YOU CAN BE SURE...IF IT'S
Westinghouse
Life-Line
MOTORS and CONTROLS

This completely Bonderized® enclosure, more than a match for the severest weather conditions, houses:

1. Life-Linestarter . . . provides dependable control and accurate overload protection.
2. AB Circuit Breaker . . . assures positive, tamper-proof circuit protection.
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YOU CAN BE SURE...IF IT'S
Westinghouse
Life-Line
MOTORS and CONTROLS

Look to

THEY HAVE WHAT YOU NEED, TOO!

SUPPLY BOVAIRD COMPANY

OFFICES AND STORES
ILLINOIS—Clay City, Grayville, Salem
KANSAS—Chase, Great Bend, McPherson, Pratt, Russell, Wichita
NEW MEXICO—Lovington
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"Buy From Bovaird"

THE *Bovaird* SUPPLY COMPANY

GENERAL OFFICES
TULSA, OKLAHOMA

31 YEARS OF PROGRESS WITH THE OIL INDUSTRY

HY-TEST

the ONLY Safety Shoes with

BoL Tan®

Sweat-resistant Leather Insoles!

H754-4
Men's 8 inch Brown Glove Blucher, Neocord outsole, Leather midsole, Neocord heel, Anchor Flange Steel Box Toe, Protector Last, BoL Tan leather insole.

ADD UP TO TWICE THE WEAR!

No other safety shoe offers the benefits of the exclusive, new *BoL Tan* sweat-resistant leather insole. HY-TEST Safety Shoes now increase worker comfort and productiveness with *BoL Tan* leather insoles in every pair.

The life of any shoe depends on the insole. That's why *BoL Tan* sweat-resistant leather insoles extend shoe life as much as 100%, because they withstand the damaging effects of foot perspiration.

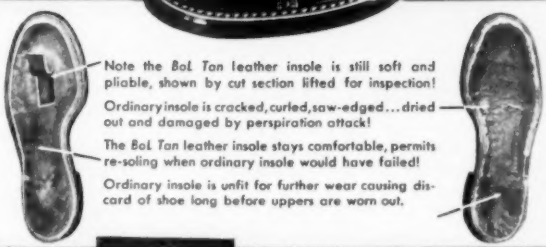
This means that your workers and all wearers of safety shoes can increase the *value* of their purchases and be more comfortable while at work when they buy and wear HY-TEST SAFETY SHOES.

H713-3
Men's Black Glove Blucher, Neocord out sole, Resist Oil midsole, Neocord heel, Anchor Flange Steel Box Toe, Protector Last, BoL Tan leather insole.

Only the BoL Tan leather insole resists the damaging effects of perspiration!

AT NO EXTRA COST!

Here are two insoles from a single pair of shoes worn in a foundry for seven months. The one from the left shoe is a *BoL Tan* leather insole; the other is a regular quality leather insole.



Note the *BoL Tan* leather insole is still soft and pliable, shown by cut section lifted for inspection!

Ordinary insole is cracked, curled, saw-edged... dried out and damaged by perspiration attack!

The *BoL Tan* leather insole stays comfortable, permits re-soling when ordinary insole would have failed!

Ordinary insole is unfit for further wear causing discard of shoe long before uppers are worn out.

HY-TEST

ANCHOR FLANGE*

SAFETY SHOES

*TRADEMARK REG. U. S. PAT. OFF.

The World's Largest Selling Safety Shoe

Division of International Shoe Company, St. Louis 3, Mo.

New York Office: Suite 1708, 225 W. 34th St.

HY-TEST SAFETY SHOES

Use this handy coupon for details on HY-TEST's BoL Tan leather insoles

HY-TEST SAFETY SHOES, Dept. OG-11
Division of International Shoe Company
St. Louis 3, Missouri

Please send me free copy of your folder explaining the advantages of BoL Tan leather insoles.

Name.....

Firm.....

Address.....

City.....Zone.....State.....

Over all types of roads,
through all kinds of weather,
Warner Electric Brakes give you

SAFE STRAIGHT-LINE BRAKING

In oil field hauling, you don't choose your road. You simply get to the job . . . through muck, mud, mire, rough terrain . . . over whatever way you find available.

That's why so many operators in the oil industry today insist upon Warner Electric Brakes for their trailers.

Warner braking is simple, sure . . . extra safe. No other system equals Warner's for simplicity . . . *easy to hook up* and service . . . gives *full clearance* under the trailer with nothing exposed to get knocked off or leak.

And with Warner Electric Brakes on your trailer, you have *two* independent braking systems. If one should fail to operate for some reason, you still have control.

The independent Warner *electric* trailer brake system *synchronizes instantly* with tractor brakes. There is no time-lag . . . braking is controlled electrically, *with lightning speed*, to give you immediate response of *all* brakes in the exact degree of power desired!

Thus, you have *completely balanced braking* of two independent systems . . . a "natural" for oil field operation. Gives you double safety, double dependability for *safe, straight-line* braking wherever your trailers must go.

OUR 25TH YEAR—WARNER ELECTRIC BRAKE & CLUTCH COMPANY, BELOIT, WISCONSIN

WARNER

ELECTRIC BRAKES

FOR TRUCK TRAILERS

HERE'S HOW ELECTRIC

"WARNER WAY" . . . all brakes reach full power together to keep tractor and trailer in line . . . safe, straight-line braking for gradual or emergency stops.

Warner dependability proved on all types of oil field hauling by Stephens & Stephens

Stephens & Stephens, trucking contractors of Graham, Texas, keep 36 trucks and trailers busy on the job of dismantling, moving and rigging up drilling rigs in Texas.

Mr. Morris Stephens reports as follows on their experience with Warner Electric Brakes:

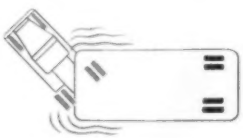
"We have used Warner Electric Brakes for about six years on all types of terrain, on short and long trips.

"This brake is exceptionally good for all types of weather. I find that electric brakes cause less trouble and are easier to maintain and keep in working condition.

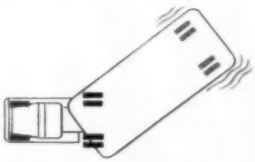
"Any operator of trucks can get along with electric brakes better than any other type."

Send now for folder shown below.

BRAKES PROTECT AGAINST JACK-KNIFING



WRONG WAY . . . when brakes aren't synchronized and tractor brakes "come in" ahead . . . jack-knife is sudden, drive wheels slide sharply. Recovery is difficult.



WRONG WAY . . . when brakes aren't synchronized and trailer brakes "build up" first . . . rear of trailer swings, then comes around into a jack-knife.

FREE! **NEW FACTUAL FOLDER "SIX STEPS TO BETTER BRAKING FOR TRUCK TRAILERS." GET YOUR COPY NOW.**

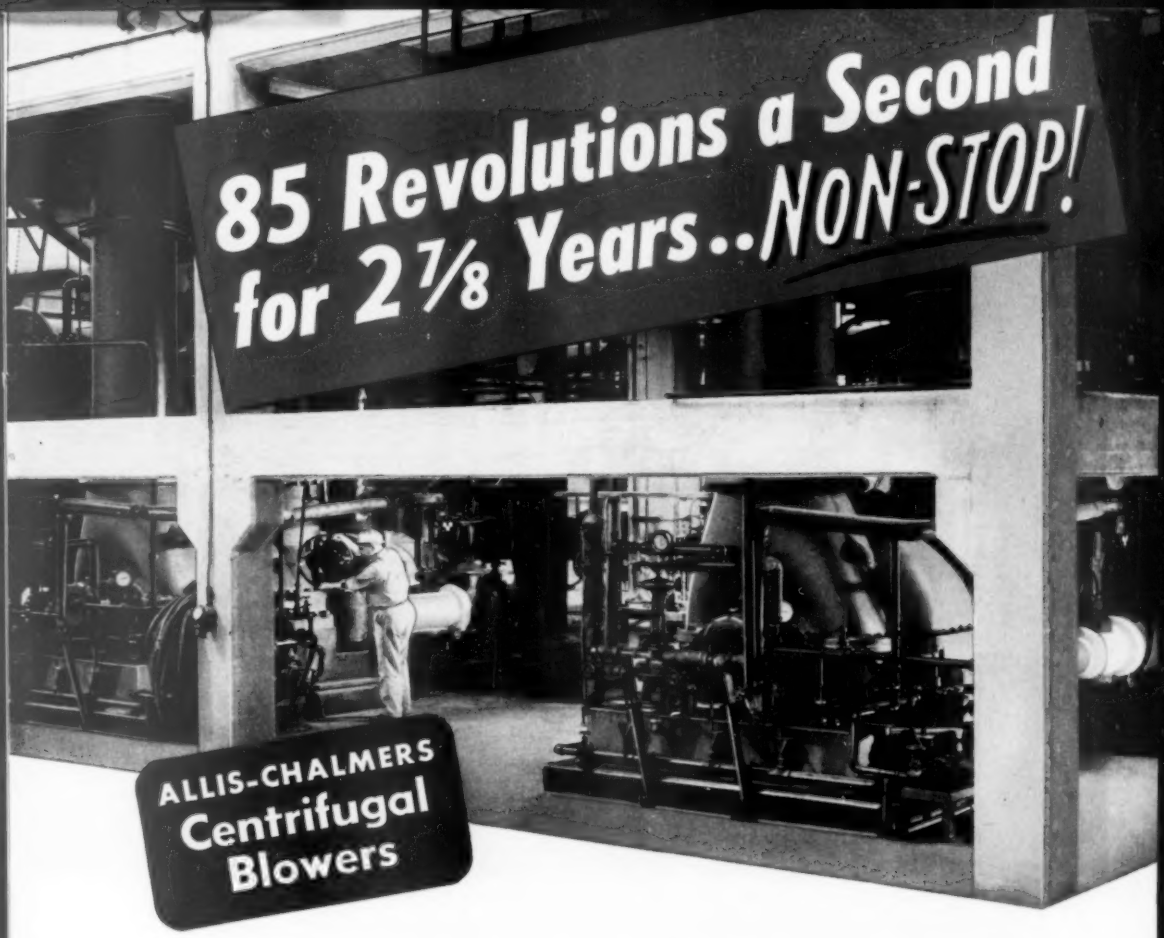
Gives important tips on driver safety through synchronized braking. Explains the precise operation, simplicity of hook-up, amazing economy and added features of *electric* braking. Write today. Warner Electric Brake & Clutch Company, Dept. OGJ, Beloit, Wisconsin, U. S. A.

JONES SUCKER RODS

More operators are utilizing the valuable assistance available through Jones trained Field Engineers in selecting the right type rods and designing rod strings tailored to individual pumping conditions. Jones recommendations are based upon scientific facts backed by experience.

THE S. M. JONES COMPANY
Division of Buffalo-Eclipse Corporation
General Office and Factory: TOLEDO, OHIO
Sales Office: Kennedy Building, Tulsa, Okla.
Export Sales Office: Buffalo International Corp.
50 Church Street, N. Y. C.

LOOK FOR THE GREEN RODS



GIVE RECORD PERFORMANCE AT CITIES SERVICE REFINING CORPORATION

AROUND THE CLOCK fluid catalytic cracking service *demands* reliable equipment. Cities Service Refining Corporation at Lake Charles, La. depends on seven Allis-Chalmers centrifugal blowers for catalyst aeration . . . rated 22,500 cfm, 17 lb G at 5100 rpm.

Six of the seven were installed in 1943. Two proceeded to set a record of 540 days, 24 hours a day, continuous operation — being shut down only for drive inspection! Two others have since run for 1058 days before scheduled inspection shutdown! Only routine maintenance has been required.

These blowers are still on the job, 24 hours a day, helping produce motor, premium, aviation gasoline and other fuels for the widespread operations of Cities Service Refining Corporation. Output is at constant volume, maintained by variable speed steam turbines.

Here are the reasons for the low maintenance and high dependability of A-C centrifugal blowers:

PURE ROTARY MOTION — precisely balanced impeller is only moving part.
FRICTION FREE INTERIOR — bearings outside casing, no internal mechanical wear.
SIMPLE LUBRICATION—oil under pressure in closed circuit, consumption is low.
STRONG CONSTRUCTION — forged steel shaft, alloy impeller cuts unit size, weight.
CAST IRON CASING — cast construction makes blower rigid, smooth, quiet.
THOROUGH TESTING — maximum and severe over-speed tests given at factory.

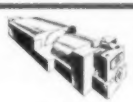
For more information or literature on this kind of highly dependable, low maintenance air and gas handling equipment, call your nearest A-C office or write to Allis-Chalmers, Milwaukee 1, Wis. New Multi-Stage Bulletin 19B6104A now available.

ALLIS-CHALMERS

Texrope is an Allis-Chalmers trademark.

A-3794

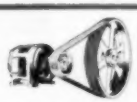
Power, Electrical, Processing Equipment for Petroleum Industry


TURBINE-GENERATORS

BLOWERS and COMPRESSORS

TRANS-FORMERS

UNIT SUBSTATIONS


MOTORS—TEXROPE DRIVES-CONTROL

CENTRIFUGAL PUMPS

At Port Arthur, Texas, the Gulf Oil Corporation operates the largest fluid catalytic cracking unit of its type in the world. Thru-put of this huge 63,000 bbl. per day cracker is approximately 20 percent greater than any similar installation. *Clark Centrifugal Compressors — five of them — serve it exclusively!*

Supplying the vast air requirements of 280 tons per hour are two Clark No. 5 Multi-Stage Centrifugal Compressors, with individual outputs of 65,000 cfm.

In addition, there are three other Clark Multi-Stage Centrifugal Compressors: two in vapor recovery and one in propane refrigeration service.

While it's significant that Clark Centrifugal Compressors were selected exclusively for this record-breaking unit, it is but one of numerous, recent cat cracker installations in which Clark Compressors are playing a key role. Wherever large volume applications are being considered, it's only natural to go to the leader that can provide *both* centrifugal and reciprocating compressors . . . the leader that can recommend impartially. Clark will do just that for you.

For information on the complete Clark Centrifugal Compressor line, request Bulletin 116.

CLARK BROS. CO. • OLEAN, N. Y.

DIVISION OF DRESSER OPERATIONS, INC.

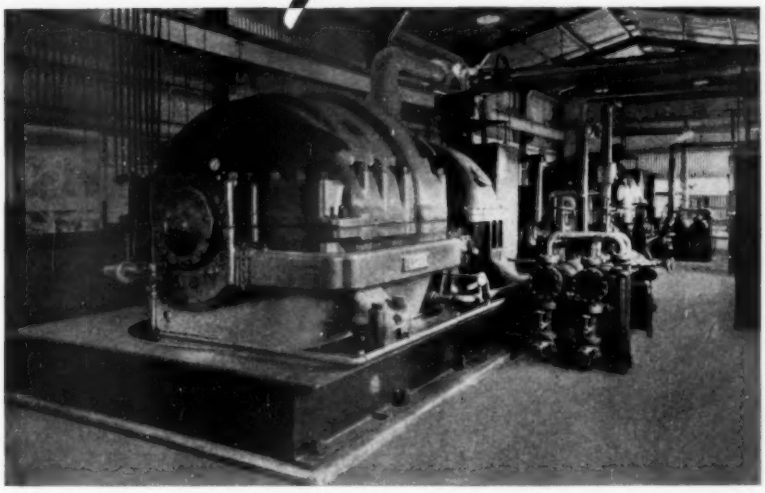
Sales Offices in Principal Cities Throughout the World

PRECISION BY THE TON . . .

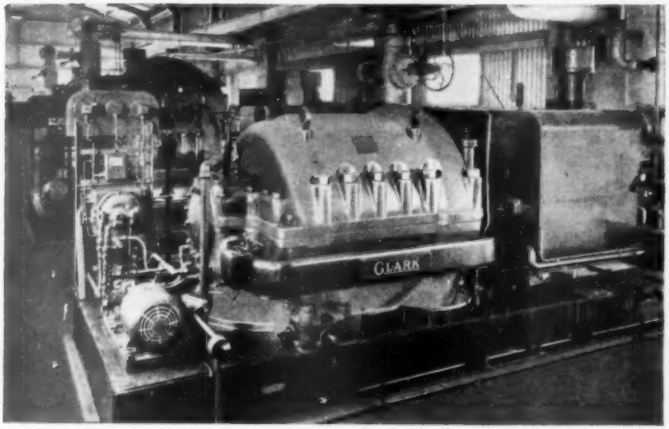
CLARK® compressors

GAS-ENGINE-DRIVEN • STEAM-ENGINE-DRIVEN • MOTOR-DRIVEN • CENTRIFUGAL

cat cracker centrifugal compressors ...*exclusively*



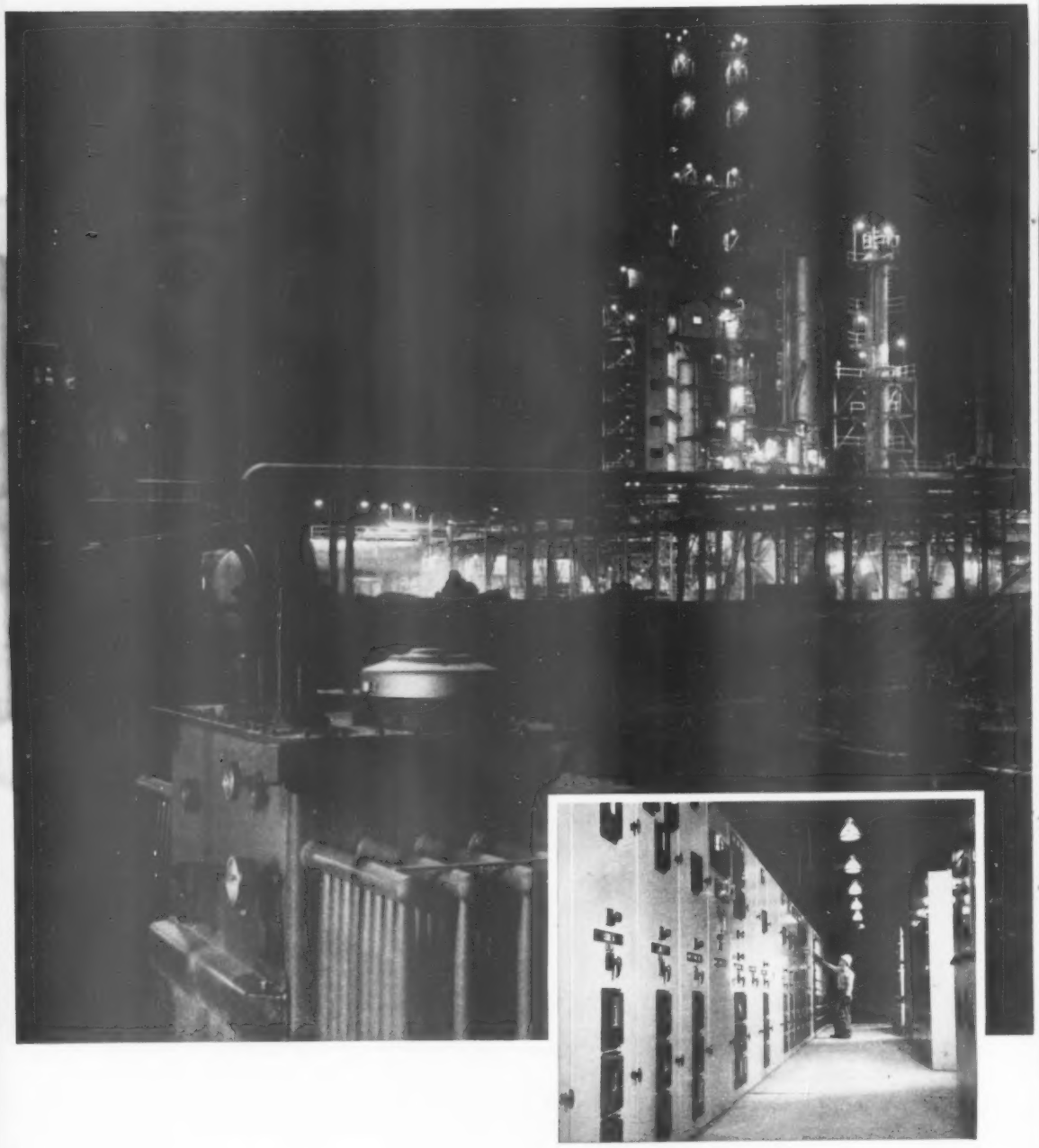
Two Clark No. 5 Multi-Stage Centrifugal Compressors, steam turbine driven, serving as main air compressors for Gulf Oil Corporation's Port Arthur, Tex., cat cracker.



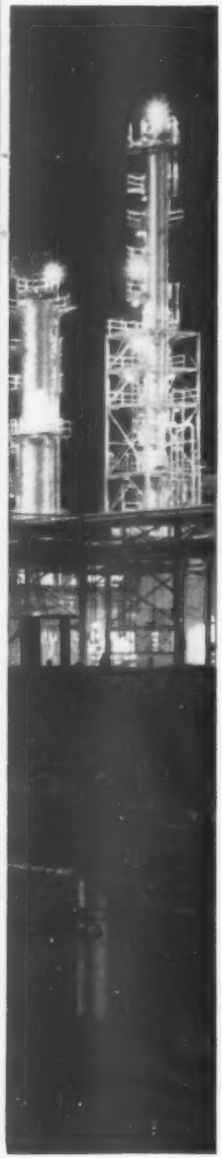
Two No. 3 and one No. 2 Clark Multi-Stage Centrifugal Compressors are used in vapor recovery and propane refrigeration service, respectively.

© 1952, Clark Bros. Co., Division of Dresser Operations, Inc.

They did what you can do
to produce more



How to get high power dependability without paying for standby capacity



When Sohio modernized and expanded the Lima refinery they needed a highly dependable power system. But they didn't want to pay for emergency stand-by capacity, a common way to achieve reliability. So engineers from Sohio, Dingle-Clark Co., and Westinghouse worked out an ingenious solution based on a sound basic principle.

Ingenious Controls Instead of Transformers

The basic principle is this: that you don't need *absolutely continuous power* for high reliability, but rather *speedy restoration of service* after disturbances do occur. So instead of providing for expensive extra transformer capacity, they developed a control system that automatically and rapidly clears trouble. And a power loss up to four seconds doesn't slow down the plant.

Devastating Tornado Didn't Stop Operation

The results of this sound planning were soon evident. Nine months after installation, a devastating tornado hit Lima and knocked out one of the two power lines serving the plant. The two key motors (catalytic cracker blower drive) were thrown out of synchronization. But both were immediately restarted by the ingenious control system. Then a second fault knocked them out again and one motor restarted to keep the process going all through the disturbances.

Disturbances are Cleared Automatically

In the first nine months of operation, there were 12 disturbances which affected these key blower motors. On ten occasions, the controls automatically restarted the motors. The other two times, the motors were restarted manually. Numerous other disturbances have failed to affect plant operation in *any* way.

Call Westinghouse Early On Your Next Project

The key to continuous power is good planning. Westinghouse would like to do this kind of planning with you. Call us in *early* when *you* build, expand or modernize. Westinghouse Electric Corp., P. O. Box 868, Pittsburgh 30, Penna.

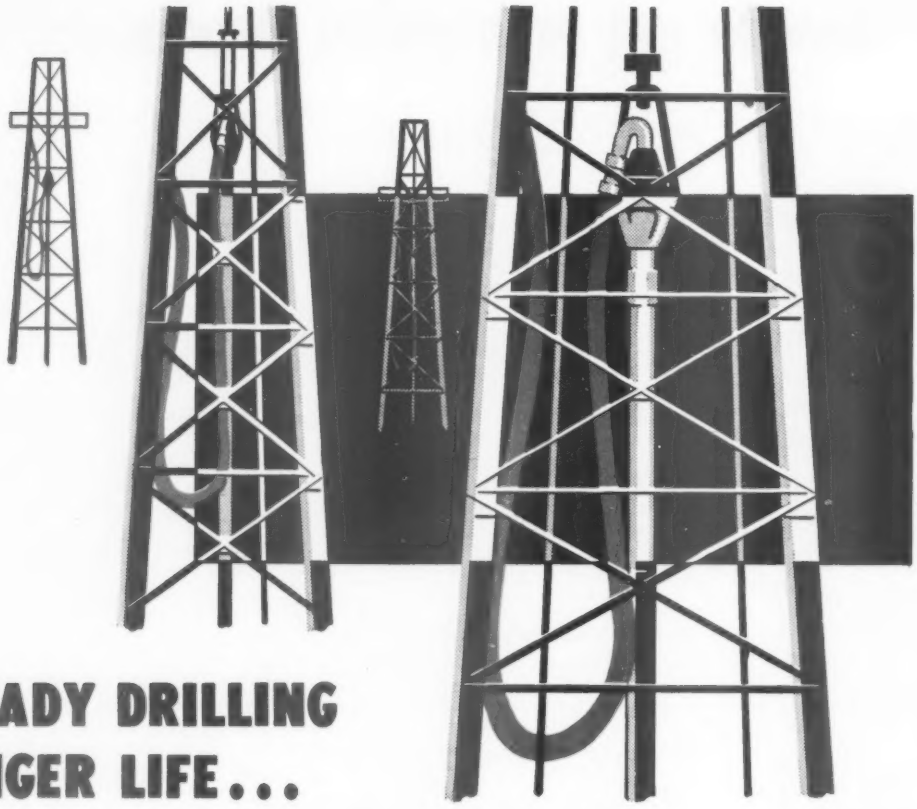
HOW SOHIO GOT HIGH RELIABILITY AT LOW COST

To keep the costs down, they built very little spare capacity into the system. Thus if there is a momentary outage, the load must be reapplied in segments. The operation is controlled by Westinghouse high-voltage switchgear, shown at left.

The big power users are the blower motors. If power outage occurs, they're automatically taken off the line by a clever "under-frequency" relay so that the rest of the plant can start up when the fault is cleared. Then in less than one minute, one of the blower motors restarts automatically. The plant keeps operating through the disturbance.

J-94906

YOU CAN BE SURE...IF IT'S
Westinghouse
EQUIPMENT FOR THE PETROLEUM INDUSTRY



STEADY DRILLING LONGER LIFE...

RAY-MAN ROTARY HOSE

How could Rotary Hose be made safer, lighter and more flexible to handle? R/M engineers answered by developing one of the great improvements in the history of rotary hose . . . Ray-Man Rotary Hose • The Ray-Man method of winding high tensile steel wire strength members under precisioned tension permits rotary hose flexibility never before equaled. Strength and steadiness under high drilling pressures give greater safety and longer life than ever before • Other features, like the Lip-Lok seal in R/M's leak-proof, built-in coupling are described in Bulletin 6898. Your nearest National Supply Company representative can tell you how the new Ray-Man Rotary Hose speeds rig work and lowers drilling costs.

DISTRIBUTED BY NATIONAL SUPPLY COMPANY IN ALL PRINCIPAL OIL FIELDS

MANHATTAN RUBBER DIVISION—PASSAIC, NEW JERSEY

RAYBESTOS-MANHATTAN, INC.

Other R/M products include: Industrial Rubber • Fan Belts • Radiator Hose • Packings • Brake Linings • Brake Blocks Clutch Facings • Asbestos Textiles • Sintered Metal Parts • Bowling Balls

"Can you furnish an efficient heat exchanger for 2 fluids of different transfer rates?"

"I need a stock design of heat exchanger for quick shipment."

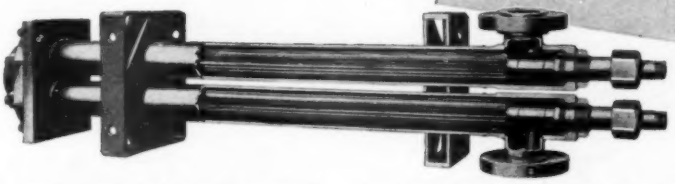
"Do you have a standardized heat exchanger that can be used for a variety of services?"

"Is it possible to get a heat exchanger with fins and tubes of different materials?"

"I want a heater system that will require least spare units."

FIVE QUESTIONS

One Answer... THE G-R TWIN G-FIN SECTION



Yes, this "Universal Heat Exchanger" meets all these needs . . . and many more. It actually has the widest range of heating, cooling, condensing and heat exchange applications of any heat transfer apparatus on the market. • The G-R Twin G-Fin Section has proved its effective design and durable construction through 20 years of service. • This unit is the simplest type of heat exchanger, easy to install, economical to maintain, and with high salvage value because of its standardized design. Write for bulletin describing the many Twin G-Fin Section advantages in detail.

THE GRISCOM-RUSSELL CO., MASSILLON, OHIO

GR-266

GRISCOM-RUSSELL

PIONEERS IN HEAT TRANSFER APPARATUS

for the petroleum industry...

MORE BASIC CHEMICALS FROM MATHIESON

Petroleum refining, like every process industry, requires certain basic chemicals. These chemicals are essential to the transformation of crude oil into hundreds of petroleum derivatives from high-octane gasoline to Diesel fuel.

Mathieson, producer of chemicals for the petroleum industry for 60 years, today supplies more basic chemicals than ever before... such important chemicals as:

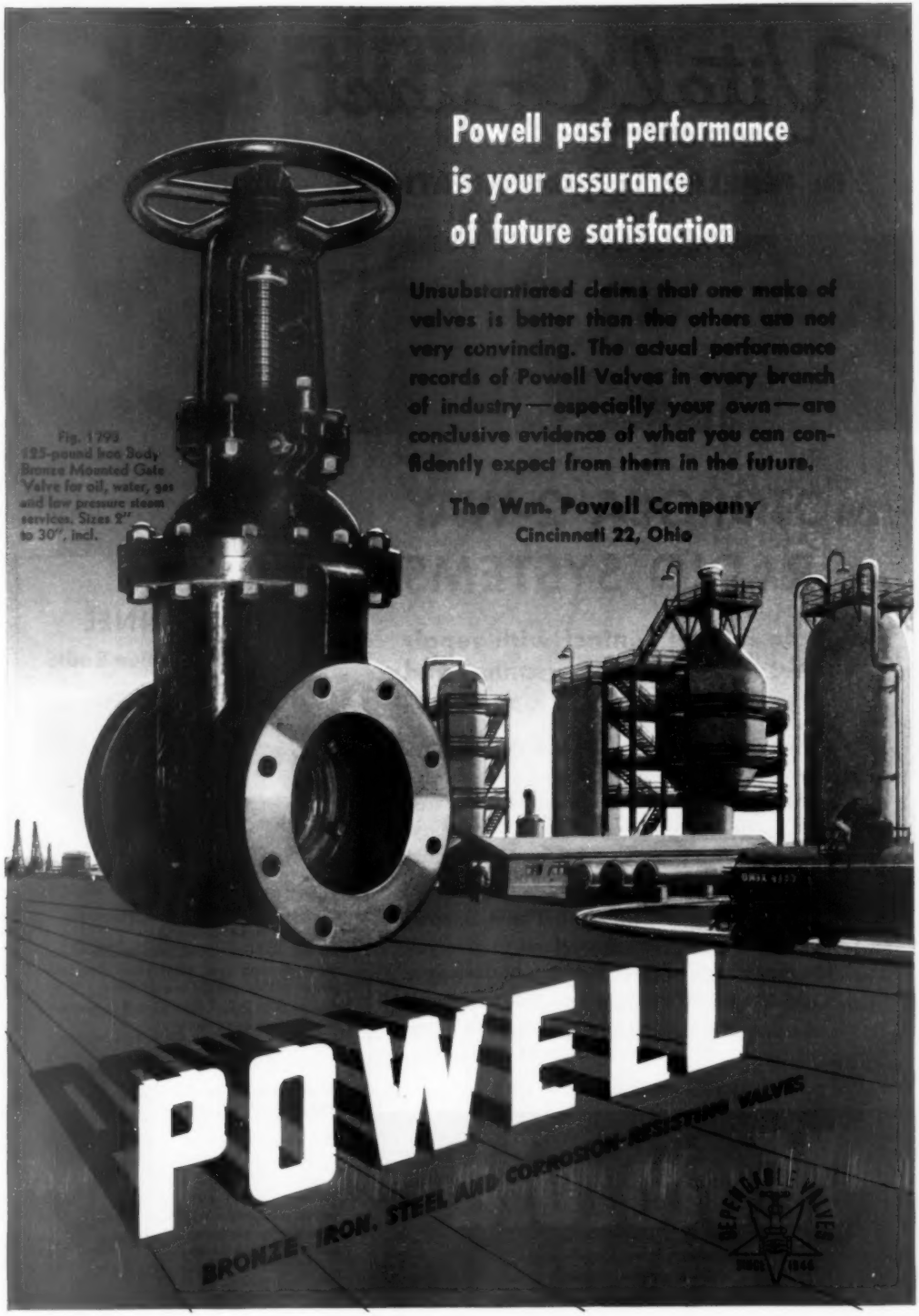
Caustic Soda	Ammonia
Sulphuric Acid	Soda Ash
Sodium Bicarbonate	Processed Sulphur
Sodium Chlorite	Diethylene Glycol
Triethylene Glycol	Dichloroethyl Ether

Calcium Hypochlorite

Currently, with market conditions uncertain, a dependable source of supply is especially important. You may be able to buy these chemicals *to better advantage* by consulting with us now. Mathieson Chemical Corporation, Baltimore 3, Maryland.

Mathieson CHEMICALS

SERVING INDUSTRY, AGRICULTURE AND PUBLIC HEALTH


Powell past performance
is your assurance
of future satisfaction
Unsubstantiated claims that one make of valves is better than the others are not very convincing. The actual performance records of Powell Valves in every branch of industry—especially your own—are conclusive evidence of what you can confidently expect from them in the future.
The Wm. Powell Company
Cincinnati 22, Ohio
Fig. 1793
125-pound Iron Body
Bronze Mounted Gate
Valve for oil, water, gas
and low pressure steam
services. Sizes 2"
to 30", incl.
POWELL
BRONZE, IRON, STEEL AND CORROSION-RESISTING VALVES
DEPENDABLE VALVES
SINCE 1846

Vital Contact

IN PIPELINE COMMUNICATIONS

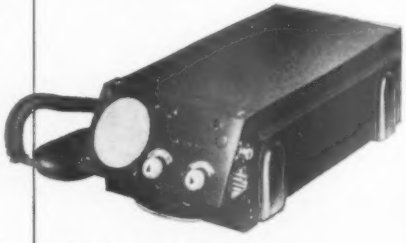
MOTOROLA 2-WAY RADIO SYSTEMS

maintain instant contact with repair crews, supervisory personnel and emergency operations

In any hard-slugging operation that requires fast, accurate timing of all crews and equipment, look to Motorola 2-way radio as step one in promoting efficiency, economy, and new operational profit!

As an investment, too, Motorola puts first emphasis on your *profit interest*. The equipment is Motorola-engineered throughout to give you the biggest dollar's worth of top performance at the lowest maintenance cost on record. It also gives you the *protected* value of obsolescence-proof equipment.

UNI-CHANNEL
Portable Base Station Radio



Quickly set up anywhere for mobile or fixed station use, this unit delivers instant, dependable radio communication year after year. Optional power supply permits use of either 117 V, A.C. or 6 V, D.C. . . . just plug it in, connect antenna and go to work!

Permanently Tuned
PERMAKAY FILTER

This unique Sensicon Permakay filter, an exclusive Motorola development, gives you sealed selectivity which permanently eliminates costly tuning adjustments.

Motorola

Communications & Electronics Division
4545 Augusta Blvd., Chicago 51, Illinois
Rogers Majestic Electronic Ltd., Toronto, Canada

keeping a tool joint "jumping"

Twice the usual service with Airco Hardfacing Alloys!

Tool joint killers: Increased drilling depths — higher penetration rates—faster rotating speeds — these are the factors that add dollars to drilling and maintenance costs.

Unless — Airco Hardfacing Alloys are given the job of holding expenses to a minimum. For with these shock and abrasion-resistant alloys you may double your tool joint life—even under the toughest drilling conditions. And of extra importance: Not only is wear greatly reduced but correct box end diameters are maintained.

If you're being faced today with tool joint problems, there's an Airco representative near you who can help. Just write or phone your local office for the information you need.

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AN AIR REDUCTION PRODUCT

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DEALERS AND OFFICES IN MANY PRINCIPAL CITIES

AIR REDUCTION MAGNOLIA COMPANY

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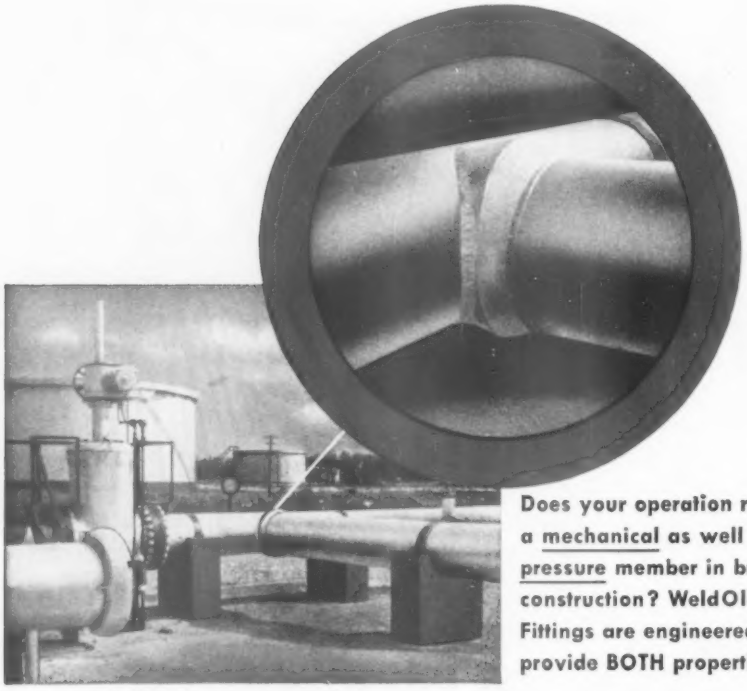
Southwestern Headquarters for Oxygen, Acetylene and Other Gases... Carbide... Gas Welding and Cutting Machines, Apparatus and Supplies... Arc Welders, Electrodes and Accessories

ENGINEERED REINFORCEMENT

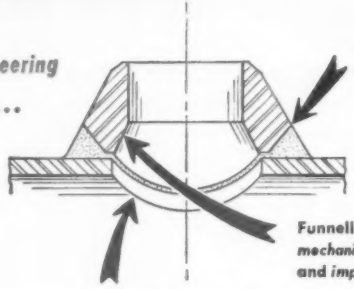
FOR YOUR BRANCH CONNECTIONS



Does your operation require a mechanical as well as a pressure member in branch construction? WeldOlet Welding Fittings are engineered to provide BOTH properties.

A big portion of your engineering job is done for you, if you...

Specify Bonney WeldOlet Welding Fittings to Insure Permanent Strength



Reinforcement where both the mechanical and internal *stresses are most severe*

Funnelled to relieve *mechanical stress concentrations* and *improve fluid flow*

Shaped and beveled for *clean, quick* and *economical installation*

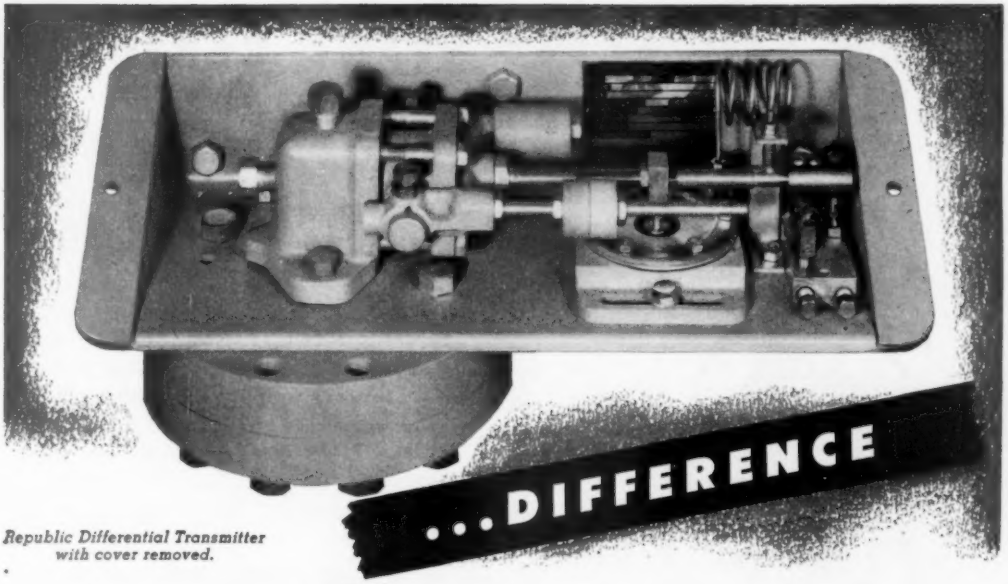
FOR COMPLETE ENGINEERING DATA WRITE FOR YOUR BONNEY W3 WELDOLET CATALOG

WELDING FITTINGS DIVISION

BONNEY FORGE & TOOL WORKS

ENG. DEPT., 366 GREEN STREET

ALLENTOWN, PENNSYLVANIA



Republic Differential Transmitter with cover removed.

Spells *PLUS* PERFORMANCE

The Republic Pneumatic Transmitter combines machine ruggedness with instrument precision to provide matchless performance in measuring flow, level, pressure or density of a wide variety fluids. By any or all of the following points, the Republic challenges comparison:

ACCURACY of the Republic force-balance principle is higher than can be consistently secured and maintained with any other method. 1/2 of 1% guaranteed.

TEMPERATURE variations of ambient atmosphere have negligible effect on the accuracy of the Republic transmitter.

CHANGES IN AIR SUPPLY PRESSURE do not affect the accuracy of a Republic transmitter to any significant extent. A 5 psi change produces an error of less than 1/10%.

CHANGES IN LINE PRESSURE—Republic differential transmitters are not affected by variations in line pressure. A patented and exclusive simple adjustment assures this protection.

SENSITIVITY—Due to the negligible motions required for complete operation of all parts, for a full scale change, no appreciable hysteresis results from reversal of direction of measurement change.

VIBRATION of any normal frequency has no effect on the Republic transmitter.

LEVELING—Since all parts are balanced, and no liquid is used for calibration, Republic transmitters need not be leveled exactly, and may be adjusted for installation in any position.

FOR TWELVE YEARS Republic Pneumatic Transmitters have delivered unmatched performance in every type of installation. Complete details of design and operation, plus numerous application suggestions are combined in Data Book, 1002. Send for your copy, today.

REPUBLIC FLOW METERS CO.

2240 Diversey Parkway, Chicago 47, Illinois

HOW 16½ ACRES STAND BEHIND

100,000 gals.

Posey Iron's 16½ acres of modern plant (under roof) stood behind the prompt delivery and sound construction of this 100,000 gallon elevated tank. Forty-one years of Posey Iron experience helped assure dependable engineering and design.

Posey Iron is equipped to do the complete job . . . from helping you determine correct type and size straight through to stress relieving, x-raying, pickling, painting and erection. The facilities of two large plate shops, an up-to-the-minute machine shop and a large foundry eliminate needless delays. Posey fabricates to meet both standard and special requirements in tanks up to all capacities. Write today for free 12-page reference bulletin.

This 16'6" vertical boring mill is one of the many tools recently added to Posey Iron's machine shop. This shop is fully equipped for the diversified machining operations demanded by Posey's different divisions.

PARTIAL LIST OF PRODUCTS

Tanks	Pressure Vessels
Dredge Pipe	Gas Holders
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Digesters	Kilns
Stacks	Stills
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Stand Pipes	Autoclaves

General Steel Plate Fabrication

POSEY IRON WORKS, INC.

Steel Plate Division

LANCASTER, PA.

New York Office: Graybar Building

ESTABLISHED SINCE 1910

DIVISIONS
Brick Machinery
Foundry
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WIRE ROPE, too, resists attack with the RIGHT KIND of muscle

Brawny chest and shoulder muscles make the gorilla a formidable foe in the eternal warfare of the jungle. Defending himself and his family, this 450-pound heavyweight stands erect and fights back with sledge-hammer blows of his mighty forearms.

In wire rope, too, it takes the right kind of muscle to resist constant attack of abrasion, corrosion, bending fatigue, load strain and shock stress.

Complete quality control of Wickwire Rope means that you can always count on the right grade of steel and size of wire; the right construction and lay of the rope for best results on your particular job.

See your Wickwire Rope distributor or contact our nearest sales office.

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THE CALIFORNIA WIRE CLOTH CORPORATION — Los Angeles • Oakland • Portland • San Francisco • Seattle • Spokane
WICKWIRE SPENCER STEEL DIVISION — Boston • Buffalo • Chattanooga • Chicago • Detroit • Emlenton (Pa.) • New York • Philadelphia

WICKWIRE ROPE
A CF&I PRODUCT

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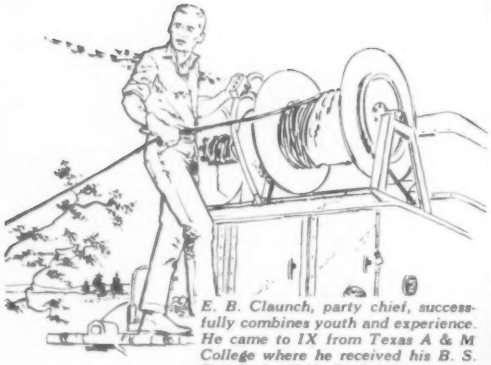
A YELLOW TRIANGLE ON THE REEL IDENTIFIES WICKWIRE ROPE

WICKWIRE ROPE
CF&I
PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION



E. B. Claunch, party chief, successfully combines youth and experience. He came to IX from Texas A & M College where he received his B. S. Degree in 1946. During his 6 years with IX he has performed many of the important duties on a geophysical crew.

Independent's EXPERIENCED Party Chiefs Pay Exploration Dividends

With an average of 16 years service in the exploration field, Independent's Party Chiefs have the professional knowledge needed to best serve you. Exploration dividends are yours when you place your confidence in the experience and knowledge of Independent's Party Chiefs and their crews.

Founded in 1932, Independent has made successful surveys in 26 states and foreign countries. More than 100 major oil producers have been served profitably by Independent Exploration Company.

POINTING THE WAY IXC FOR THE DRILL

Independent's Experience Merits Your Confidence

Independent *Geophysical Surveys*

EXPLORATION COMPANY

1973 WEST GRAY ★ HOUSTON, TEXAS

ESTABLISHED 1932

• In and out of Oil Fields • Laying Pipelines
• Transporting Power and Pumping Units
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FASTER! EASIER! AT LOWER COST!

When jobs call for extra power and traction off-the-road, depend on the broad-lugged, deep-shouldered GENERAL L. C. M. Shock-absorber construction and more rayon cords per inch assure more strength, more original miles—more recap miles.

When jobs call for some work off-the-road, most on, use the GENERAL H. C. T. Extra thick saw-tooth tread for more traction, more high-speed safety. Tough shoulder cleats prevent snags, cuts, bruises. More original, more recap miles.

Make Every Worn Tire Work Longer for More Profit!

Your GENERAL TIRE DEALER will KRAFT SYSTEM RECAP Worn Tires with the New GENERAL Truck Tire Tread of Your Choice

KRAFT SYSTEM RECAPPING
A GENERAL TIRE SERVICE

You're throwing away money when you throw away worn tires or accept an ordinary "adjustment" for them. Let your General Tire Dealer—a tire expert—restore worn tires with famous factory controlled Kraft System Recapping. You choose from the complete line of on and off-the-road new General Tire treads and he'll put that tread on your worn tire. He can do sectional repairs too. Get Kraft System Recapping—get more profit from every tire.

SPECIFY GENERAL TIRES ON YOUR NEW EQUIPMENT

PUTTING PRODUCTION IN PIPELINING! . . .

Houston Contracting Company lays 9,000 feet of 26-in. pipe in a 10-hour day with "Caterpillar" Diesel Tractors equipped with high production Trackson PIPE LAYERS. Doping-wrapping crews also keep "on schedule" . . . with these job-proved tools.

You can establish daily production schedules and keep to them — with Trackson PIPE LAYERS!

These strong left arms of "Caterpillar" Diesel Tractors lift, lower, carry and bend pipe. They have separate clutches on the boom and load line drums and heavy-duty automotive-type transmissions to give operators precision control of their loads. Frames are all-welded, securely mounted to track frames for thousands of work hours without interruption. Broad tracks of the "Caterpillar" Diesel Tractor teammates gear efficient tractor power to the earth to carry Trackson PIPE LAYERS *anywhere* to do their work.

These features—much-copied, but never equalled—enable Trackson PIPE LAYERS to keep production where you want it. Your "Caterpillar" Dealer can give you delivery information and help you plan your spreads. Call on him or write direct.

CATERPILLAR TRACTOR CO., Peoria, Illinois

TRACKSON

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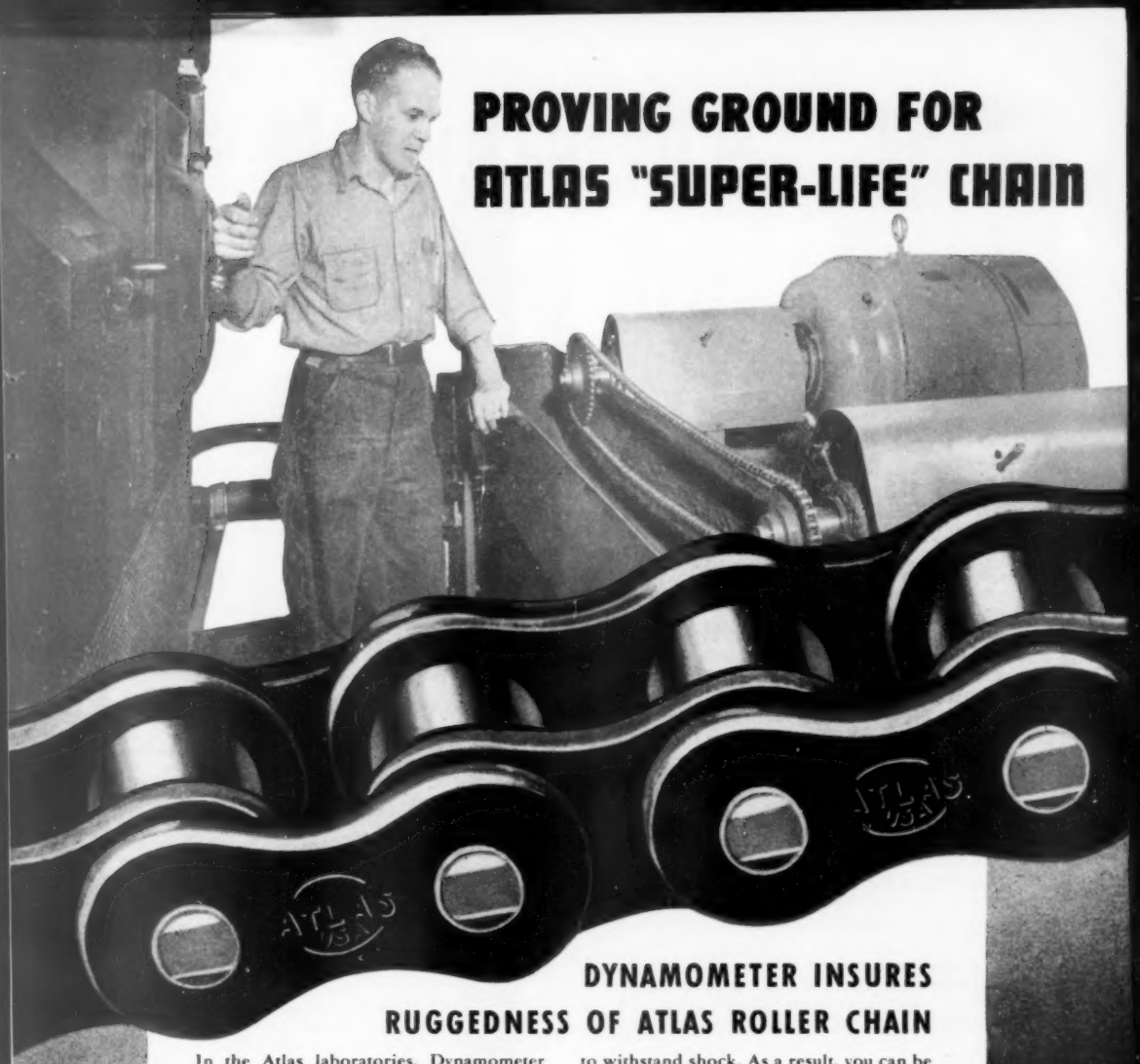
A SUBSIDIARY OF CATERPILLAR

TRAXCAVATOR SHOVELS
PIPE LAYERS
ANGLEFILLERS



PROVING GROUND FOR ATLAS "SUPER-LIFE" CHAIN

DYNAMOMETER INSURES RUGGEDNESS OF ATLAS ROLLER CHAIN

In the Atlas laboratories, Dynamometer tests give final proof of the strength, life and economy of Atlas "Super-Life" Roller Chain. Here the results of all Atlas specifications and methods of manufacture are checked for top performance, under varying conditions of speed, load, and sprocket characteristics.

The Atlas Dynamometer provides a complete test of Atlas Chain's wearability, fatigue life, load-carrying capacity, and ability to withstand shock. As a result, you can be certain that every link of Atlas Chain will deliver more years of trouble-free service, more production for your power transmission dollar.

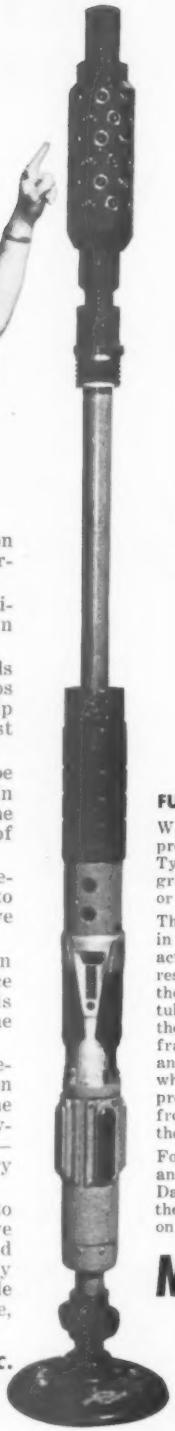
For greater efficiency, more economy, on every power drive, install Atlas "Super-Life" Roller Chain—the chain that speeds up production, cuts down maintenance. Write today for the new Atlas Catalog and Handbook.

ATLAS CHAIN & MANUFACTURING CO.
PHILADELPHIA 24, PENNA.

ATLAS

ATLAS ROLLER CHAIN

How this hold-down anchor keeps its grip



Using packers for acidizing or other production techniques? Then take a good look at the Guiberson hold-down anchor. It has lots to offer.

The Guiberson hydraulic anchor acts as a positive means of holding tubing and packer down when the well is pressured below the packer.

How? The moment tubing pressure exceeds casing pressure, the anchor automatically grips the pipe. Each little case-hardened piston-slip independently holds fast against any thrust from above or below.

To make sure the vital anchoring power will be there when it's needed, the slips operate within Monel® inserts. That way, there's no danger the slips will "freeze" in the inserts as a result of rusting.

Monel combines its well-known corrosion resistance with strength and resistance to wear to protect your equipment against the destructive attacks of sour crudes, acid, brine and sand.

As has been proved time after time, you can always count on dependable, trouble-free service from "Monel-protected" equipment. It holds down corrosion—even in the most troublesome fields!

Right now, because so much is taken for defense, Monel and other Inco Nickel Alloys are on extended delivery. However, by ordering the equipment you want well in advance—and by giving NPA rating and full end-use information—you'll improve your chances of getting delivery when you need it.

And any time, of course, that you run into problems involving metals for oil field use, we hope you'll write us. Inco's Technical Service and Corrosion Engineering Section may already have the answer handy. If not, they may be able to help you find it. Either way, there's no charge, no obligation.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street, New York 5, N. Y.

FULLY AUTOMATIC

When tubing pressure exceeds casing pressure, the slips of this Guiberson-Type "H1" hydraulic hold-down anchor grip the pipe and hold against upward or downward thrust.

The slips are case-hardened, and operate in Monel inserts, thus assuring positive action together with maximum corrosion resistance. Among the principal uses for the "H1" are: (1) Holding packer and tubing down while well is pressured below the packer, as in acidizing or formation-fracture processes; (2) Anchoring tubing and packer in gas or water injection wells where tubing pressure will exceed casing pressure; and (3) Preventing tubing from "breathing" in pumping wells where the fluid level is low in the casing.

For more detailed information about this anchor, write The Guiberson Corporation, Dallas, Texas, through whose courtesy the illustrations and technical information on this page were supplied.

Monel

. . . your partner in progress

INCO

Fast Motor Service Wherever You Are

ALLIS-CHALMERS "Certified" SERVICE

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Sioux City—Smith Elec. & Supply Co.

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Salina—Cent. Kans. Elec. Mach. Co.
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Kansas City—Boese-Hilburn Elec. Co.
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Barabee—Utility Transformer Equip. Co.
Green Bay—Beemster Electric Co.
Milwaukee—Dietz Electric Co.
Wausau—Electric Motor Service
Wisconsin Rapids—Staub's Elec. Wks.

ALLIS-CHALMERS CERTIFIED SERVICE SHOPS are independent service shops which have met rigid standards for ability, experience, equipment and business integrity. They use factory approved methods and parts and do your work promptly at a fair price.

Of course, Allis-Chalmers Certified Service Shops give good service on any electrical equipment, of any make. Tear out this ad and save it, or write the name of the A-C Certified Service Shop nearest you in your address book. Allis-Chalmers, Milwaukee 1, Wisconsin. A-3864

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Applied . . .
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by Allis-Chalmers Authorized Distributors, Certified Service Shops and Sales Offices throughout the country.

CONTROL — Manual, magnetic and combination starters; push button stations and components for complete control systems.

TEXROPE — Belts in all sizes and sections, standard and *Vari-Pitch* sheaves, speed changers.

PUMPS — Integral types from ¾ in. to 72 in. discharge and up.

AXELSON MATCHED SEATS and BALLS

5 grades to handle every well condition

The five grades, each made in both rib and flat types offer a selection that makes it possible for the operator to strike a sensible balance between original cost and service life. Each, for its purpose, is the finest seat-and-ball that money can buy.

Axelson deep well plunger pump, "TLE" tubing liner type.

AXLOY (high chromium, high carbon, molylodenum.) Recommended for almost every well condition except where extreme corrosion and abrasion conditions exist.

Send for Bulletin 5003 giving complete information.

AXELSON *Chosen first....to last!*

PETROLEUM PUMPING EQUIPMENT

OUR 65th YEAR

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

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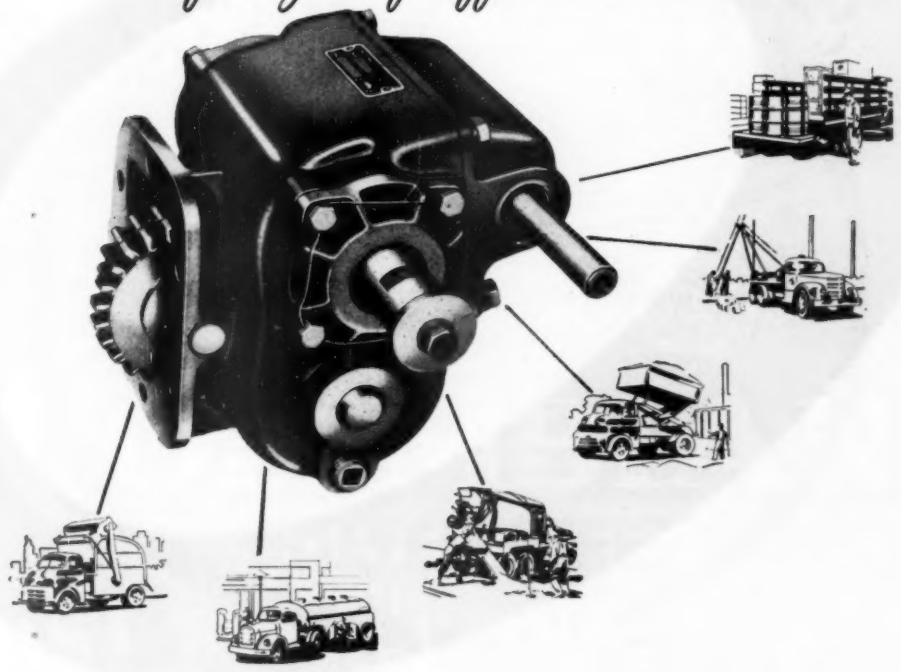
SPECIALISTS IN SERVICE

POWER where you want it . . . when you want it

for dozens of different Service Jobs



Spicer Brown-Lipe Power Take-Off and Power Take-Off Joints are available in a wide range of models to meet every service requirement. These units are considered standard by the automotive industry, and are more widely used than any other similar types of equipment.

Spicer Brown-Lipe Power Take-Offs are designed to meet all operating conditions of continuous or intermittent service. All gears used are made from chrome nickel molybdenum steel forgings, annealed and case-hardened, insuring the longest possible service life under severe operating conditions.

Experienced Spicer engineers will be glad to help adapt Brown-Lipe Power Take-Offs to the particular requirements of your product, wherever it may need to serve.

48 YEARS OF Spicer SERVICE

SPICER MANUFACTURING

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Don't *"get in a stew"* over corrosion problems!

When you're faced with a difficult corrosive condition, avail yourself of Metal Goods Corporation's long experience in supplying corrosion-resistant metals.

No other warehouse has more technical and school-of-hard-knocks experience in battling corrosive attacks. This explains why the petroleum industry turns to Metal Goods Corporation year after year to assist it in bringing about a reduction in costly shutdowns.

To get the facts about your specific corrosion problem... to get the most dependable corrosion-resistant alloys . . . call your nearest Metal Goods Corporation representative.

Please call, wire, or write the following Metal Goods Corporation representative nearest you.

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Phone: GOodfellow 1234

Kansas City 16, Mo.
1300 Burlington
Frank D. Hogan
Phone: NOrclay 3516

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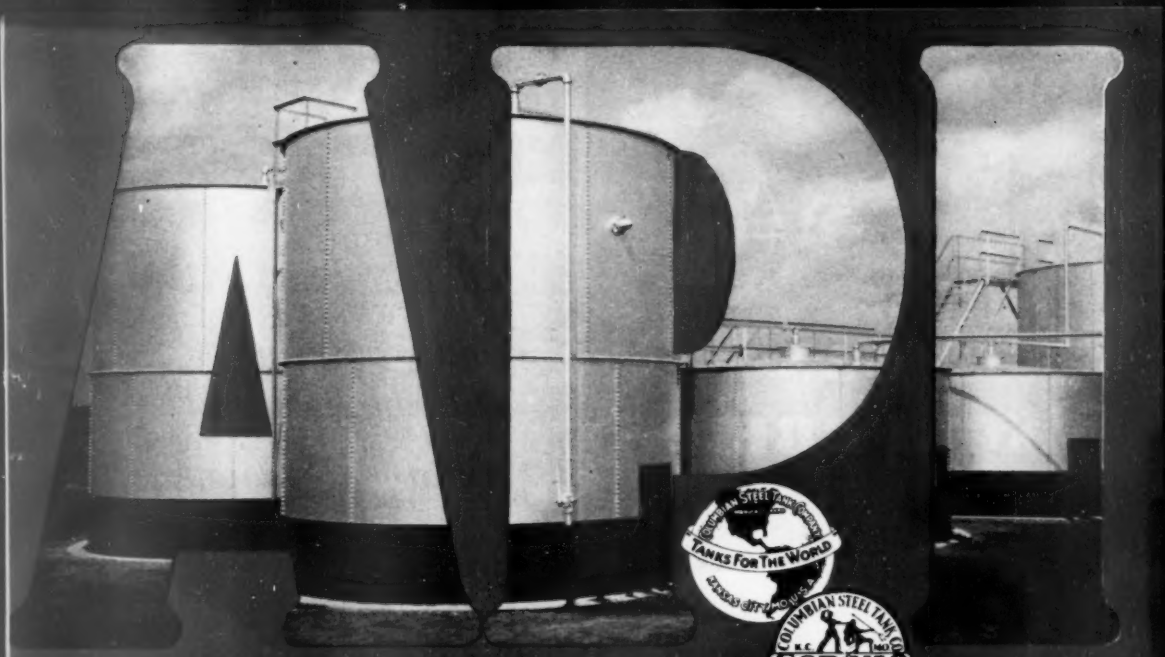

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CC-24E

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WHEN YOU ORDER VALVES FROM THE COMPLETE LUNKENHEIMER LINE

YOU SAVE IN INVENTORY — because Lunkenheimer Valves are gauged to such close tolerances that parts are readily interchangeable and replaceable. With a *few* Lunkenheimer Valves in stock, you have the assemblies required to meet many service conditions — with no delay for costly "tailoring" of parts.

1

YOU SAVE IN MAINTENANCE —because Lunkenheimer Valves are service-engineered for *particular* applications. They give you trouble-free performance in all the services for which they are recommended. And the Lunkenheimer line is *complete*.

2

YOU SAVE IN PRODUCTION — because you needn't worry about costly "down-time." Lunkenheimer Valves stay on the job — month in, month out. The finest alloys and outstanding craftsmanship assure you of long, trouble-free service.

3

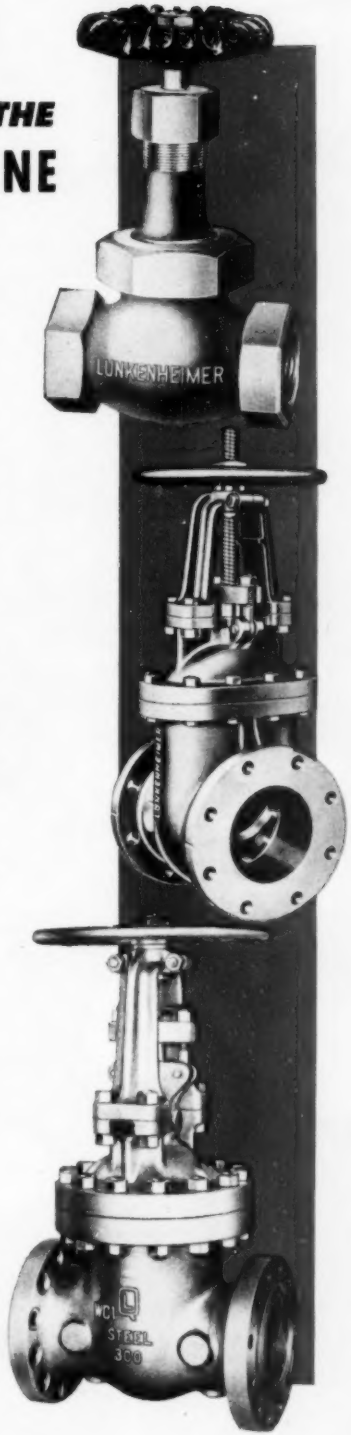
YOU SAVE IN ORDERING — because the nation-wide network of Lunkenheimer "blue-chip" distributors gives you fast local service. You can fill *all* your needs from the complete Lunkenheimer line — save shipping costs . . . simplify your ordering and handling.

4

YOU SAVE IN FINAL COST — because Lunkenheimer Valves offer you unmatched quality in materials, design, and workmanship. Whether you need bronze, iron, or steel valves — in whatever size or pattern —you can count on dependable performance from the *complete* Lunkenheimer line.

5

WRITE FOR literature on Lunkenheimer Bronze, Iron, or Steel Valves. Where possible, describe your typical valve applications. For quick local service, call your Lunkenheimer Distributor. The Lunkenheimer Co., Box 360F, Cincinnati 14, Ohio.



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LUNKENHEIMER

THE ONE *Great* NAME IN VALVES

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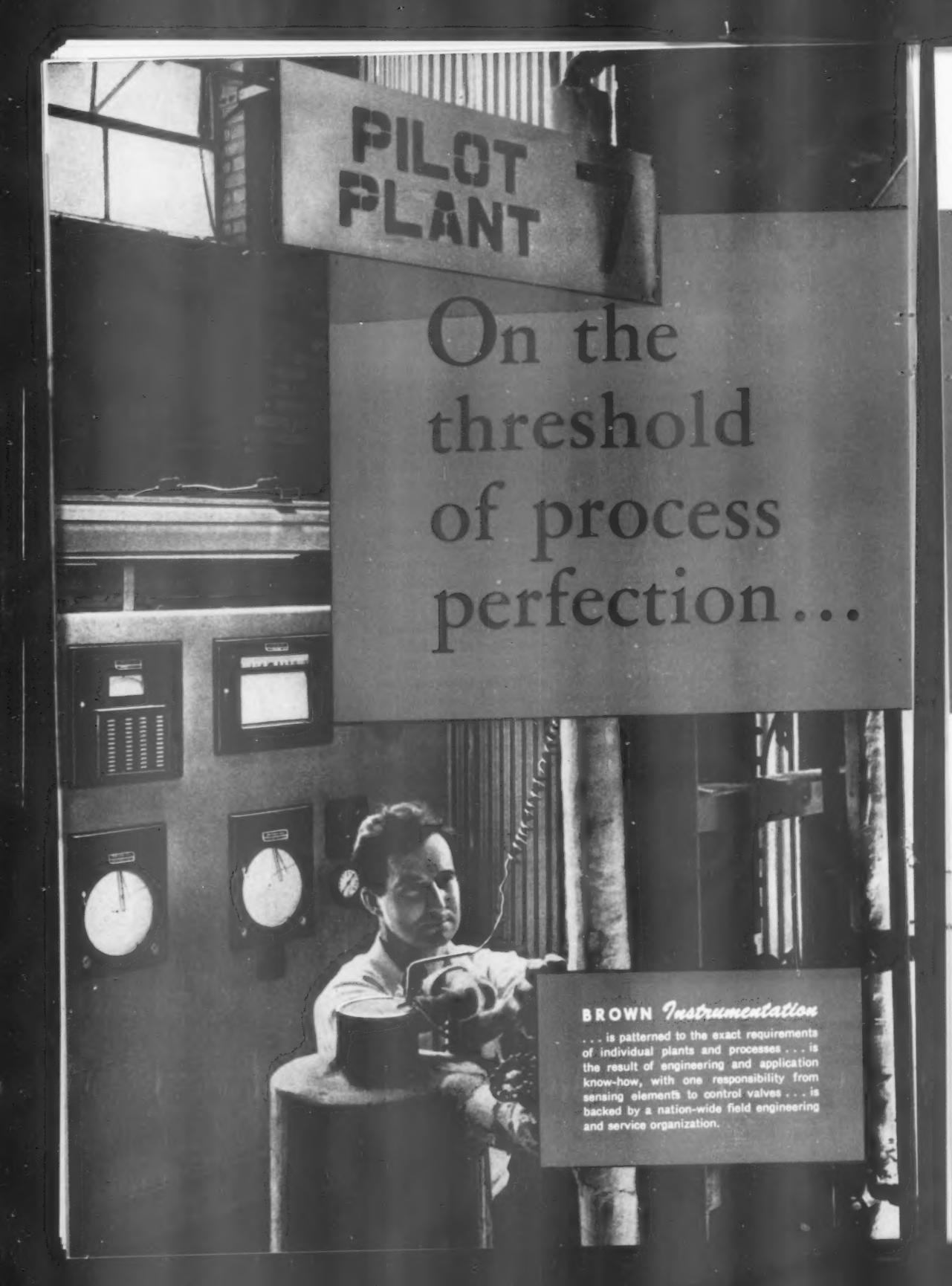
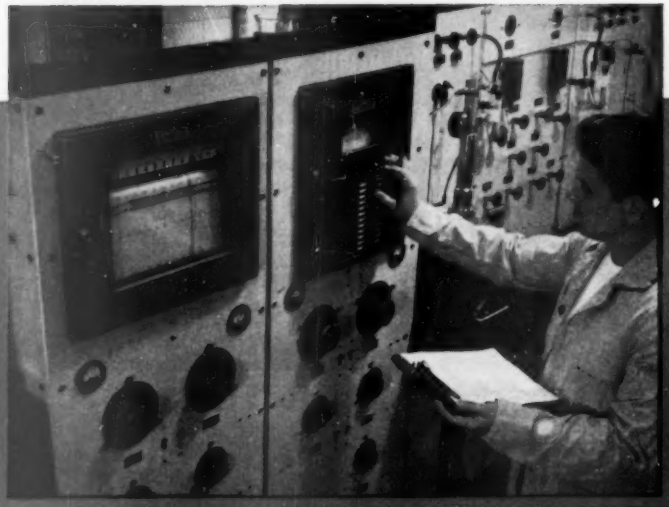

PILOT PLANT
On the threshold of process perfection...
BROWN Instrumentation
. . . is patterned to the exact requirements of individual plants and processes . . . is the result of engineering and application know-how, with one responsibility from sensing elements to control valves . . . is backed by a nation-wide field engineering and service organization.



PROVING processes in the pilot plant stage can save untold millions of dollars in "on-stream" operations. But bridging the gap between fluid ounces per hour in the laboratory and hundreds or thousands of barrels per hour in the plant takes considerable doing.

Thorough instrumentation in the pilot plant provides . . . (1) *a saving in scientific man-hours*, through the centralization of critical data which eliminates the hand logging of hundreds or even thousands of points . . . (2) *easy and rapid interpretation of data*, through automatic coordination and recording in chart form . . . and (3) *process simplification*, through a complete understanding of control problems well in advance of full-scale operations.

Add to these advantages the fact that, with instruments, pilot studies are accomplished in much less time . . . for instruments *accelerate* research. Investigate the wide application possibilities of Brown Instrumentation. Our local engineering representative is qualified to discuss your requirements . . . and he is as near as your phone.

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First in Controls

Important Reference Data

WRITE FOR A COPY OF 84-PAGE BULLETIN NO. 15-14, "INSTRUMENTS ACCELERATE RESEARCH"... AND NEW BROCHURE, "TOMORROW IS TODAY."

when time is money!

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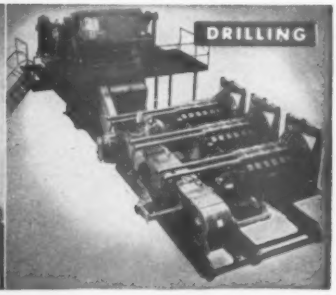
ENSIGN CARBURETION

for DEPENDABLE low cost

GAS ENGINE PERFORMANCE



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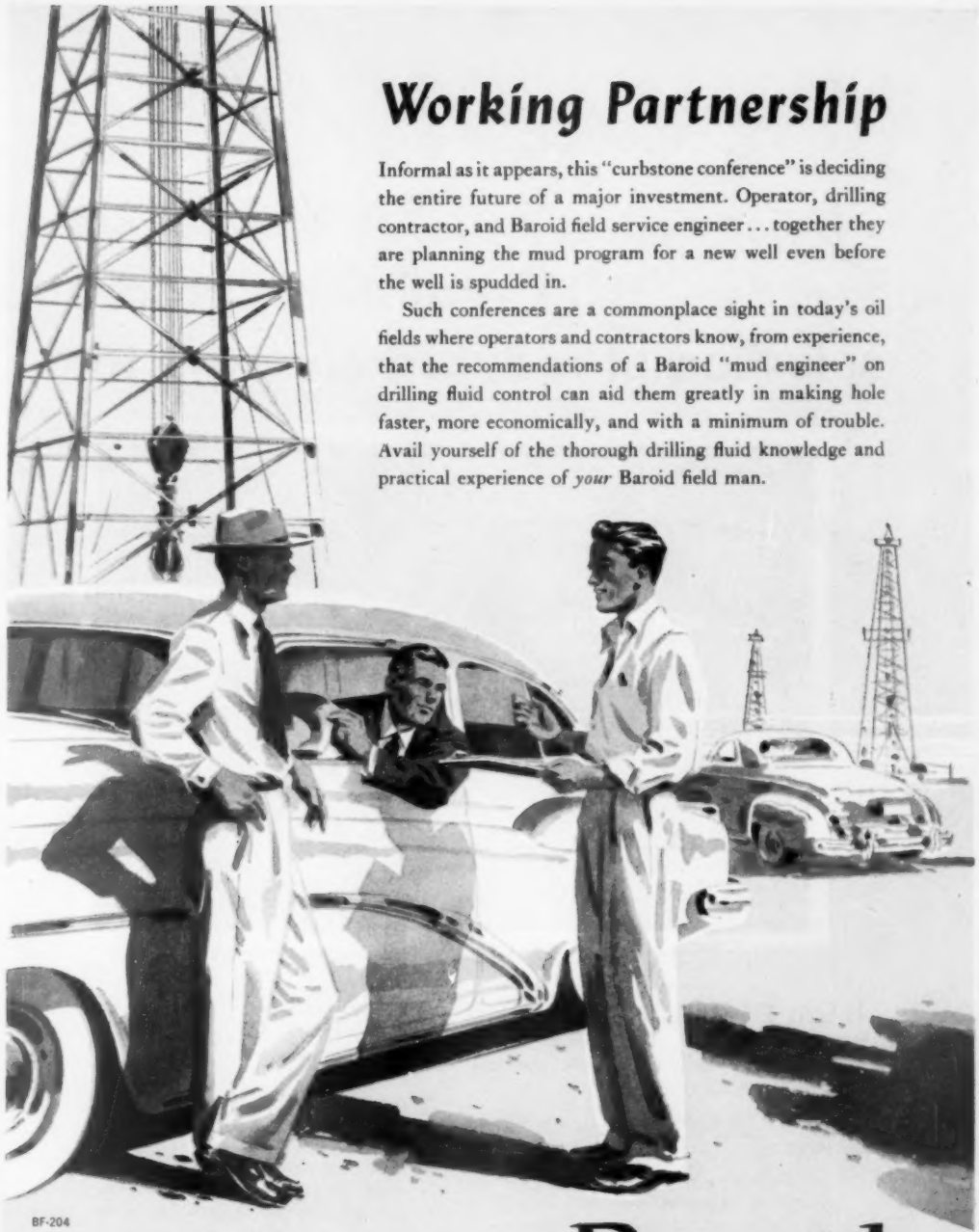

Working Partnership

Informal as it appears, this "curbstone conference" is deciding the entire future of a major investment. Operator, drilling contractor, and Baroid field service engineer... together they are planning the mud program for a new well even before the well is spudded in.

Such conferences are a commonplace sight in today's oil fields where operators and contractors know, from experience, that the recommendations of a Baroid "mud engineer" on drilling fluid control can aid them greatly in making hole faster, more economically, and with a minimum of trouble. Avail yourself of the thorough drilling fluid knowledge and practical experience of *your* Baroid field man.

BF-204

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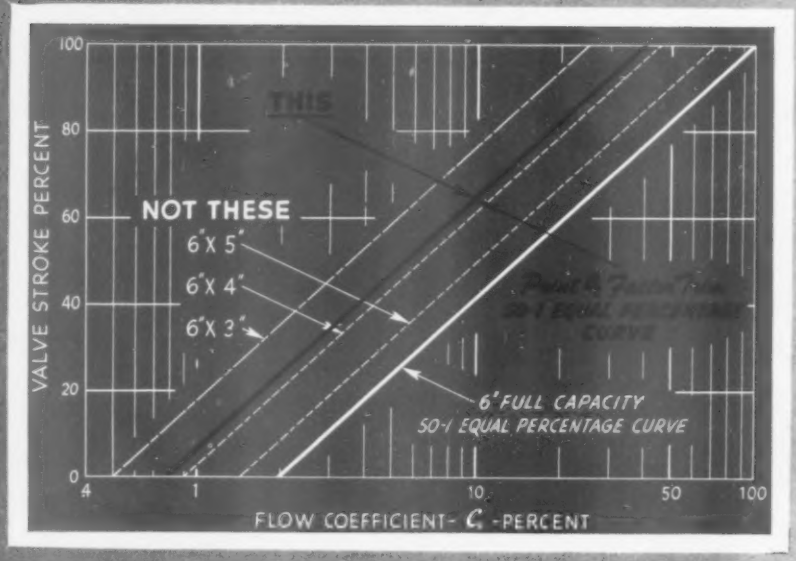
One Size, Not Three

Masoneilan *Point* 4 *Factor Trim* offers the ONLY realistic approach to selection of reduced capacity trim



It is a DEMONSTRABLE Fact

that for a given size top-and-bottom guided valve only one size reduced capacity trim is:

Desirable from an engineering standpoint because . . .

(a) properly designed wide-range valves with full capacity trim will handle a vast majority of control problems.

(b) if any reduction is required, it must be substantial to be of any advantage.

(c) any sound design must be based on a reduction in seat ring diameter.

(d) rule-of-thumb trim reductions based on nominal *pipe* sizes are unnecessary and merely complicate the sizing problem.

Practical from manufacturing and operating standpoint because . . .

(a) mechanical strength is retained with standard guide and stem diameters and standard stroke, in combination with maximum reduction in seat diameter.

(b) reduction in number of parts simplifies stock problem.

(c) forged and cast forms insure complete uniformity of parts.

MASONEILAN

Point 4 Factor Trim

is the answer to those few types of applications where reduced capacity trim is required. It is available in V-port and solid turned designs for double or single seated Valves (sizes 1¼" through 12") and in a wide variety of materials.

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A HIGH C_Q PRODUCT

Oil and gas men know the importance of "bone dry" petroleum products. They also know that ALCOA *Activated* Alumina is one of the oldest . . . most reliable . . . thoroughly proved drying agents in the petroleum industry.

ALCOA *Activated* Alumina, earning its reputation the hard way, has *proved* its superiority, year-in, year-out, in hundreds of steady, reliable dehydration jobs. Particularly efficient in drying furnace oil and gasoline, instrument air and other gases, it has effectively solved the problems of moisture in finished products in storage or in pipe lines.

ALCOA *Activated* Alumina is highly adsorptive . . . easy to handle . . . abundantly available . . . and easily regenerated. It is one of the few desiccants that will not shatter on contact with water. It has high resistance to crushing, shock and abrasion. Moreover, this highly inert aluminum oxide dries to *lower dew points* than any other commercial adsorbent!

ALCOA *Activated* Alumina can speed up your processes . . . can save *your* money. Let us tell you how. Write to: ALUMINUM COMPANY OF AMERICA, CHEMICALS DIVISION, 618-L Gulf Building, Pittsburgh 19, Pennsylvania.

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Another Great New CHRYSLER INDUSTRIAL

Now . . . Chrysler offers you a choice of *two* great V-8 Industrial Engines. The new 160 horsepower 276 cubic inch displacement Model 19 Engine has virtually the same features as the 180 horsepower Model 20. The highly efficient hemispherical combustion chamber with overhead valve arrangement . . . positive-action full-flow oil filter . . . dual carburetion . . . precision-balanced crankshaft . . . greater horsepower to weight ratio—all are combined in an engine that is second to no other similarly rated engine for performance and economy of operation. For more information on Model 19 or any other of the basic Chrysler engines, see your Chrysler Industrial Engine Dealer, or write: Dept. 1311, Industrial Engine Division, Chrysler Corporation, Trenton, Michigan.

New home of the Chrysler Industrial Engine Division at Trenton, Michigan. This new plant, with more than a million square feet of floor space, gives the Chrysler Industrial Engine Division tremendously increased production, testing, research and developmental facilities. These greater facilities were made necessary by the substantial increase in applications of Chrysler Industrial Power and will better enable the Division to keep pace with tomorrow's even greater demands.

CHRYSLER
Industrial Engines
HORSEPOWER WITH A PEDIGREE

CHAPMAN LIST 960

the one Forged Steel Gate Valve that gives you this 4-WAY PROTECTION

Extra Protection Against Even Unusual Stress is provided by extra-strong stem-and-wedge-gate connection.

Repairs and Replacements Are Reduced by super-hardened seat rings and gate faces of stainless steel.

Longer-Lived Body and Yoke are of forged steel. And bolted follower has no threads on yoke to corrode.

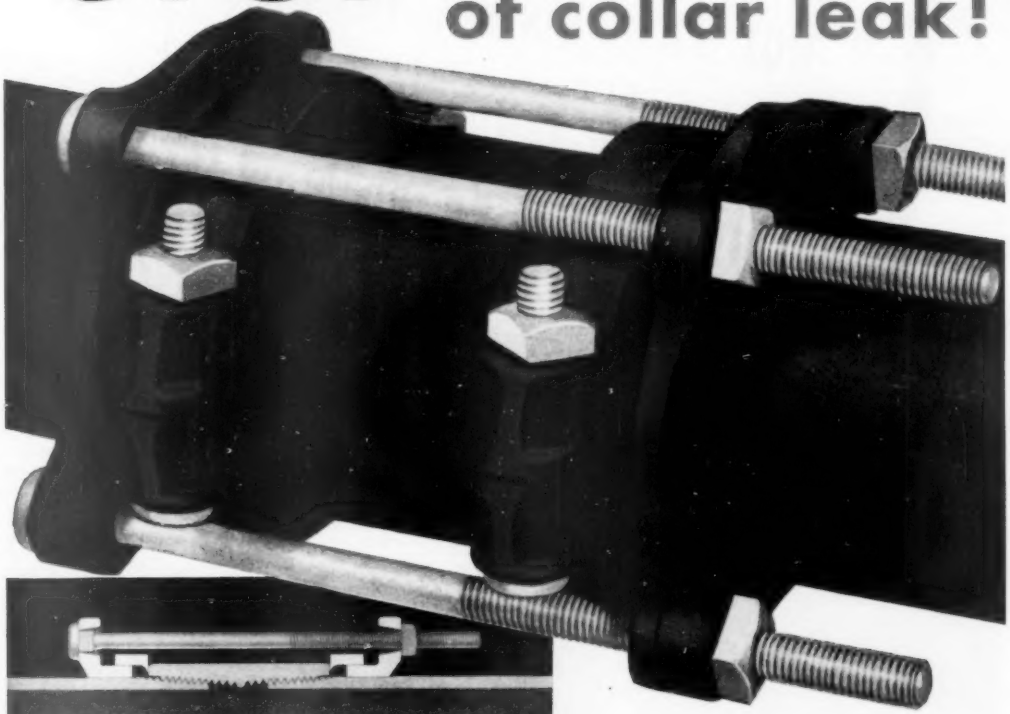
No Seizing or Galling of Gate Faces because List 960's gates (when furnished with certain types of trim) are hardened by *Malcomizing* (patented Chapman process) to a minimum of 800 Brinnell.

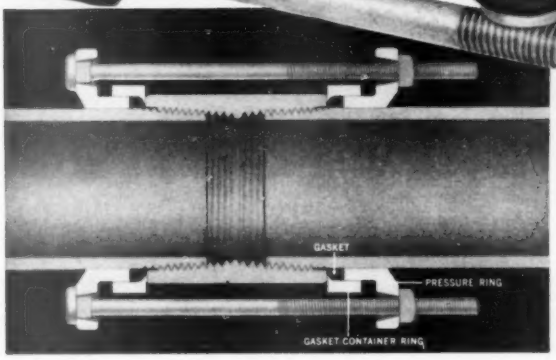
An exceptionally wide range of services is covered by this small forged steel gate valve . . . giving you the same consistent top level performance on many different jobs.

Chapman List 960 Forged Steel Gate Valves are manufactured in sizes from ½" to 2" inclusive, and in these 2 types: (1) Rising stem with yoke (shown), and (2) Rising stem with inside screw. Bonnet joints are either gasketed or metal-to-metal. Pressure range: 2000 lb. at 100°F. — 380 lb. at 1000°F. For higher pressures, specify List 990. Send for illustrated Catalog No. 10.

THE CHAPMAN VALVE MFG. CO., INDIAN ORCHARD, MASS.

STOP every type of collar leak!





SKINNER-SEAL collar leak clamp with sealed gasket

SKINNER-SEAL Collar Leak Clamps are standard equipment with most companies, for permanent repairs on oil and gas lines. Gasket is sealed by gasket container rings — pressure is sealed in . . . air, moisture and gasket-destroying soil conditions are sealed out. The pipe, not the collar, guides the packing into the leak. Rugged pressure rings, large diameter, high tensile steel, electroplated bolts and rigid container rings make the Collar Leak Clamp *effective under any pressure*. Handy wrench enclosed in each carton of 3 clamps. Sizes 2" — 12" incl. in stock at supply stores! M. B. Skinner Co., Est. 1898, South Bend, Ind.

SKINNER-SEAL COLLAR LEAK CLAMP

Our case history files will help you solve any refinery tubing problem

● If you buy refinery tubing, you probably know quite a bit about steel analyses already. But it's hard to keep track of *every* steel tubing analysis, and just how it stands up under the countless combinations of heat, pressure and corrosive materials.

As the world's largest manufacturer of tubular products, we have a file of authentic case histories that covers many of the refinery tubing problems you will encounter. A problem that is new to you may be old to us. We may have encountered it before and solved it with one of our 23 different steel tubing analyses.

You can really use this information today, when so many grades of steel are in short supply. We'll help you select alternates that may do as good a job—sometimes at a lower cost than before.

Save valuable time by checking with us first when you are going to select tubing. There's no obligation, and we'll be glad to give you all the help we can. Write to National Tube Division, United States Steel Company, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

23 Steel Tubing Analyses

let us help you select the best for your job

Low Carbon	5 Cr, ½ Mo	17 Cr
Low Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	27 Cr
½ Cr, ½ Mo	5 Cr, ½ Mo, Ti	18-8
1¼ Cr, ½ Mo	7 Cr, ½ Mo	18-8 Ti
2 Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2¼ Cr, 1 Mo	8 Cr, 1 Mo	18-8 Mo
2½ Cr, ½ Mo, ¾ Si	9 Cr, 1 Mo	25-20
3 Cr, 1 Mo	12 Cr, Al	

All National Seamless Tubing is pierced from a solid billet of high-quality steel. This is the one manufacturing method that removes all doubt concerning uniform wall strength.

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UNITED STATES STEEL

TRADE PAPER EDITION
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ENGINEERING *News*

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VERSATILE JET EDUCTORS BLEND OILS THE EASY WAY

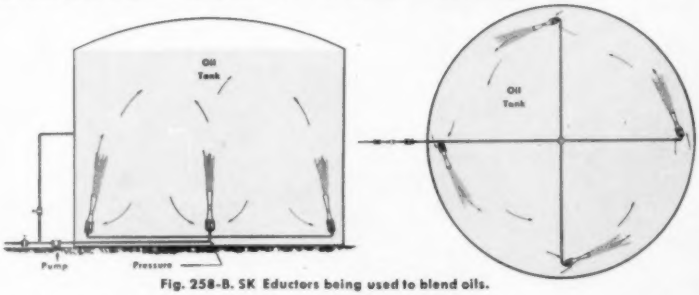


Fig. 258-B. SK Eductors being used to blend oils.

Applications of SK Jet Eductors include lifting, pumping, mixing, and agitating of liquids and the handling of solids and slurries.

Specifically, in the petroleum industry, they are currently being used in pumping and mixing operations in oil treating systems (such as sweetening-alkylation), for introducing anti-knock fluids and coloring matter into gasoline, and for continuous blending, acidifying, causticizing of oils, for removing spent filter clay, and for tank mixing and proportioning operations.

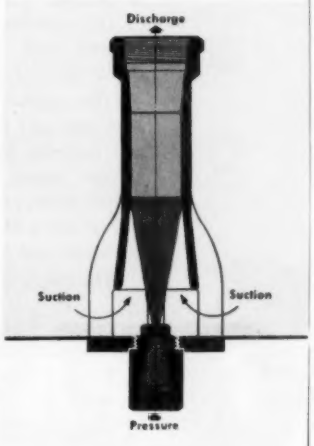
In all of these operations, jet eductors provide certain definite advantages—based, to a great extent upon the fact that they are simple in design and construction, require little maintenance or supervision and yet are very efficient.

A typical application is shown in Fig. 258-B. Here, five 8″ SK Fig. 258 Internal Mixing Eductors are being used to blend, recirculate and agitate oils in a 100 ft. tank. Initially, transfer pumps are used to fill the tank through the eductors. As soon as the liquid submerges the eductor nozzle, blending begins. In this particular instance, the eductors are arranged to entrain 3 gallons of tank oil for each gallon of motive oil. Other ratios are possible.

As shown by the sectional drawing, Fig. 258, motive oil, under pressure, issues from the eductor nozzle and entrains oil from the tank. The two are thoroughly mixed in the eductor throat and are then discharged. After the tank is full, the mixing is completed and stratification is prevented by using the pump to recirculate oil from the top of the tank through the eductors where oil from the bottom of the tank is again entrained.

This illustrates but one of many uses for only one of many types of SK Jet Eductors. For other interesting examples of how eductors can be applied, request a copy of Bulletin 2-M.

Fig. 258. Photo and sectional view of an SK Internal Mixing Eductor.



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BUCKS COUNTY, PA.
Representatives In Principal Cities

BIG Tractor-shovel with BIG push

4-wheel drive PAYLOADER®

The big 1½ cu. yd., 75 horsepower Model HM "PAYLOADER" has proven itself in the oil industry as a valuable, versatile earth mover. It gets to the job faster under its own power at speeds up to 16 mph . . . has traction and flotation to work on poor grounds . . . can excavate, load trucks, backfill, bulldoze, spread, pull, push, lift and carry. It's a many-purpose handyman for the pipe liner, the driller and the refiner.

This tractor-shovel also makes a hit with operators because it rides easy and has a big comfortable seat, power-boosted steering and fingertip hydraulic control. Four speeds *reverse* as well as forward permit as fast operation in both directions as the job conditions allow, and there's a choice of gasoline or diesel power. Once you've seen a Model HM in action you'll understand why hundreds of owners and operators are its enthusiastic boosters.

The Frank G. Hough Co., 749 Sunnyside Ave., Libertyville, Ill.

WRITE for catalog on the 1½ yd. Model HM or the six other "PAYLOADER" sizes down to 12 cu. ft. bucket capacity.

SAY "HUFF"

PAYLOADER®

THE FRANK G. HOUGH CO. • Since 1920

How to land strings under proper tension

Reminders of Good Casing Practices:

Definite instructions should be available for the proper string tension, also on the proper landing procedure after the cement has set, to apply this tension. The purpose is to avoid critical stresses or excessive and unsafe tensile stresses at any time during the life of the well. In arriving at the proper tension and landing procedure, consideration should be given to all factors such as well temperature and pressure, temperature developed due to cement hydration, mud temperature, changes of temperature during producing operations, and the movement of the freeze point during the life of the well.

Reprinted by permission from "API Recommended Practice RP 5 C1: Care and Use of Casing, Drill Pipe and Tubing."

REPUBLIC *Electric Weld* CASING and TUBING

- **Make up fast**
- **Resist pull out**
- **Resist collapse**

. . . because they're uniformly round, uniformly strong, uniform in wall thickness and diameters. Republic Electric Weld Casing and Tubing are cold-formed from high ductility steel, and full normalized for uniform structure. Casing is cold sized to further increase its high yield point. Uniform depth of tough steel under thread roots guards against pull-outs. Clean, full-formed threads stab, spin-in and tong-up fast . . . and tight. Write for literature.

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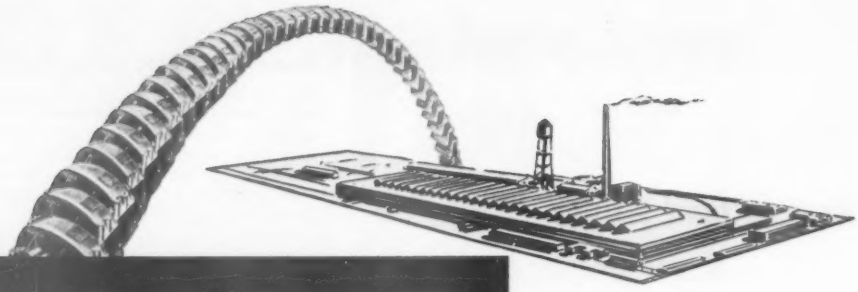
REPUBLIC *Electric Weld* NORMALIZED CASING AND TUBING

REPUBLIC STEEL

Other Republic Products include Line Pipe—Carbon, Alloy and Stainless Steels—Upset Studs, Bolts and Nuts—Electrunite Heat Exchanger Tubes



OVER ¼ MILLION HORSEPOWER AND NOT A SINGLE FAILURE

That is the record of Farrel® speed increasers in pipeline pumping service.

These units were first developed in a standard series twenty years ago. Since then, although hundreds and hundreds have been installed throughout the oil industry, *not one has ever failed on the job.*

This amazing record is worth remembering the next time you are in the market for speed increasers. It provides a virtual guarantee of trouble-free performance.

The modern line of Farrel speed increasers consists of 49 standard sizes with speed ratios ranging from 1:1 to 12:1. For higher ratios, units using two sets of gears are supplied with ratio range from 12:1 to 40:1.

For further information, send for a copy of Bulletin No. 448A. No cost or obligation.

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FB-780

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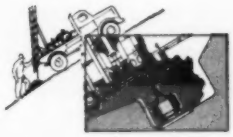
Fully Compensated Drive
—Multiple, free-acting differentials compensate for the differences in travel of all wheels. This reduces drive line strains, eliminates needless tire wear and scuffing.

Proper Weight Distribution
—Only a true 4x4 or 6x6 can give you the added weight on the front wheels needed for necessary traction to work in any footing, terrain, or weather.

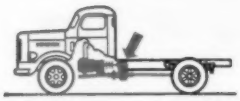
Advantages like these speed up oil field operations because FWDs

get thru where others fail!

There's an FWD for Every Job
—FWD models for Geophysical work, from the Light-Duty LD to heavy-duty 6x6 transporters, are dependable units, designed for rugged oil field service.



High Climb Oil Sump
—Keeps oil pump constantly submerged. Valuable in Geophysical service—prevents "oil starvation" of engine. An exclusive FWD feature that allows truck or truck-operated tools to work on steepest inclines or slopes.

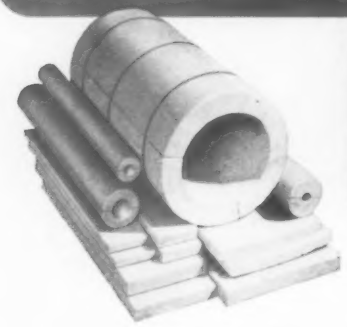


Auxiliary Transmission
—Doubles the number of gear ratios...provides extra low gear ratios for work at extreme low speed. Available on all FWDs, as optional or standard equipment.

Get More Work Done At Less Cost Per Job...
Designed with the help of veteran oil men, FWDs have many performance-boosting features. An FWD will get supplies and equipment through where other rigs fail . . . handle more work per day, more jobs per year . . . cost less to service and maintain. Your FWD Dealer will be happy to give you all the facts on these versatile tools. Contact him or write direct to FWD. THE FOUR WHEEL DRIVE AUTO CO., Clintonville, Wis. *Canadian Factory,* Kitchener, Ontario.

Built by the makers of America's Foremost Heavy-Duty Trucks

Pattern for the Future...



MODERN CONSERVATION PROJECT—the new Snyder Gasoline Plant, Snyder, Texas, operated by Sunray Oil Corp. for some 30 companies and 60 individuals. Plant-process heating equipment and steam lines are insulated with Kaylo Heat Insulation. General contractor—The Fluor Corporation, Ltd., Los Angeles, Calif.; insulation contractor—Industrial Insulators, Inc., Houston, Texas.

Leading Refiners Are Switching to KAYLO HEAT INSULATION

The growing trend to Kaylo Heat Insulation is a logical result of the outstanding combination of advantages offered by this revolutionary heat-saving material.

Kaylo Heat Insulation, a hydrous calcium silicate, has high insulating value over a wide temperature range. It is *effective* up to 1200°F.—thus eliminating the need for combination coverings in nearly all operating conditions.

In addition, Kaylo Heat Insulation has these excellent physical characteristics: it is insoluble in water and incombustible. It has dimensional stability . . . high strength . . . light weight — properties vital to a superior heat insulation.

Its ease of handling, cutting and fitting simplifies application—saves time on the job. With these important extra advantages, *at no extra cost*, little wonder that leading refiners are switching to Kaylo Heat Insulation.

KAYLO® . . . *first in calcium silicate*

For complete details on Kaylo Heat Insulation, write Dept. N-235, Owens-Illinois Glass Company, Kaylo Division, Toledo 1, Ohio.

SEE OUR CATALOG IN THE REFINERY CATALOG

. . . pioneered by OWENS ILLINOIS Glass Company

MAIN OFFICE: TOLEDO 1, OHIO—KAYLO SALES OFFICES: ATLANTA • CHICAGO • HOUSTON • NEW YORK • PITTSBURGH • ST. LOUIS

WHY seat misalignment doesn't cause this Darling Valve to leak!

NO gate valve body ever made is entirely immune to distortion caused by line stresses and temperature changes. Yet even slight distortion can throw the seats out of alignment—probably the most common cause of leaky valves and costly replacement.

That's one reason why Darling gate valves, with their unique wedging principle combined with fully revolving double discs and parallel seats, have the jump on other valves. They easily, *automatically* adjust for valve body distortion, cinching tight, leak-proof closure without destructive strong-arm tactics. Most important, you avoid costly down-time and repeated maintenance headaches.

But that's not all! Actually, this Darling principle offers several other equally important time-and-money-saving advantages. In plant after plant they add up to trouble-free performance and longer service life with a very minimum of attention.

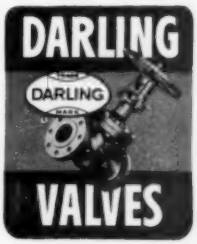
GET ALL THE FACTS

Send for descriptive cast steel valve Bulletin No. 5003.

DARLING VALVE & MANUFACTURING CO.
Williamsport 1, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ontario

NOTE: *Darling gate valves are made in a wide range of sizes, types and constructions, including solid and slotted taper-seat wedge types, for all kinds of normal and corrosive services in pressures up to 1500 pounds.*

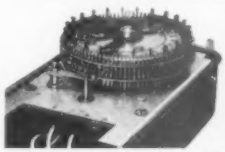


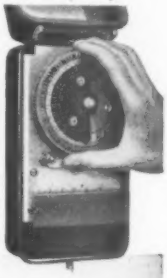
FOR PLUS VALUES, JOB-PROVED AGAIN AND AGAIN

THIS IS "Oil Country" CONTROL

Built the way oil men told us to build it

Cutler-Hammer 9589 oil well pumping controller with 3 coil overloads and time delay relay.





Program Time Switch automatically schedules pumping, set up easily by pull tabs—one for each 15 minute interval. Day omission feature also available, for non-operation any selected days of week.

You know and we know that there are no operating conditions anywhere as tough and rough as oil country conditions. And that is why Cutler-Hammer Engineers went to the oil country when they designed their oil well pumping control, talking to operators, production men, maintenance crews, getting the story on the spot.

To beat the heat, C-H engineers made the case finish of sun reflecting aluminum, built in louvres at the top and bottom to drain off the heat at the top and bring in fresh air at the bottom. The contact structure is out in the open where heat radiates freely. You never see a C-H Controller with door propped open to keep it working.

To beat the dust, and dirt, and insects and rain, they not only louvred but bronze-screened and baffled the ventilator openings; they used the famous C-H dust safe Vertical Contacts that shed dust; they neoprene-gasketed the timer mechanism and provided an excess torque clock motor that keeps going even if dust accidentally gets in.

They provided 2 coil overload relays where conditions are normal, and 3 coil overload relays where single phasing is a common occurrence.

They provided undervoltage relays where manual restarting is desirable, and automatic time delay relays where automatic staggered restarting is wanted. The mounting arrangements are universal so you can easily change from one to another. Or you can short out the staggered starting for instantaneous automatic restarting.

You can change the on-off sequence simply by pulling out small, accessible tabs in 15 minute increments. You can have an automatic day omission feature if you want it.

Other features are unit lightning arresters that tell at a glance if one is blown—but *won't* blow up the works with it. There's a plastic coated wiring diagram with spare parts listing, that doesn't become smudged and unreadable from greasy handling.

These oil well pumping controllers are used everywhere, proved everywhere, preferred everywhere. Try one and *see why*. CUTLER-HAMMER, Inc., 1453 St. Paul Ave., Milwaukee 1, Wisconsin. *Associate*. Canadian Cutler-Hammer, Ltd., Toronto.

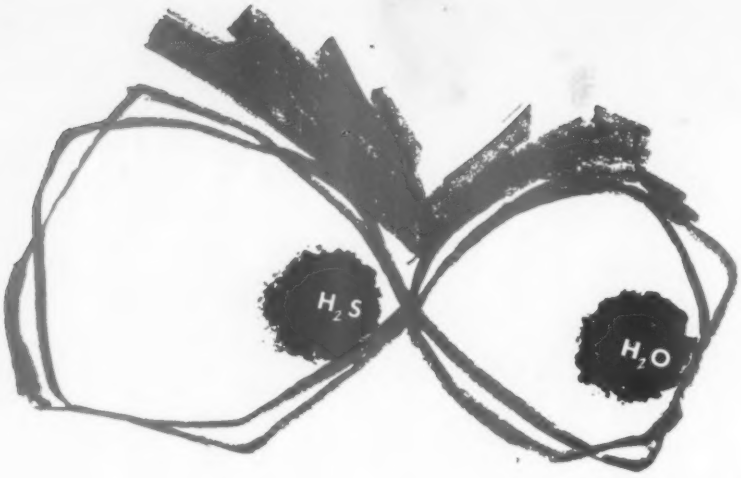
MEMBER AMERICAN PETROLEUM INSTITUTE

LESS COST PER FOOT

LESS COST PER FOOT
CHRISTENSEN
DIAMOND PRODUCTS

CHRISTENSEN
DIAMOND PRODUCTS CO.

1937 SOUTH 2nd WEST • PHONE 6-8738 • SALT LAKE CITY, UTAH



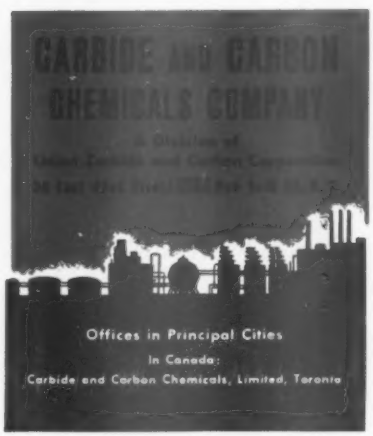
H_2S and H_2O need not cause you any Woe...

When you use	To remove
MONOETHANOLAMINE or DIETHANOLAMINE	H_2S
DIETHYLENE GLYCOL or TRIETHYLENE GLYCOL	H_2O

More corrosive hydrogen sulfide is being removed from hydrocarbon gases with monoethanolamine and diethanolamine than by any other method. Some companies are even realizing a profit from this impurity by converting it to elemental sulfur or selling it as concentrated H_2S.

And water can readily be removed from high pressure transmission lines with diethylene glycol and triethylene glycol. Thus you maintain capacity and avoid pipe line and regulator clogging.

Twenty years ago the introduction of monoethanolamine, diethanolamine, diethylene glycol, and triethylene glycol by Carbide and Carbon Chemicals made possible efficient and economical methods of removing H_2S and water from hydrocarbon gases. During this period we have compiled considerable data on the properties and use of these helpful chemicals. If you are constructing new facilities, or are replacing, enlarging, or modernizing your present equipment, we believe these data will save you time and money.


CARBIDE AND CARBON CHEMICALS COMPANY
Offices in Principal Cities
In Canada:
Carbide and Carbon Chemicals, Limited, Toronto

PEERLESS TYPE PR

REFINERY AND CHEMICAL PROCESS PUMPS OFFER YOU ALL THESE FEATURES:

1. Center-line-mount design; heavy duty construction

2. Full range of sizes; many available from stock

3. Top suction or end suction, top discharge design

4. Designed particularly for pumping all hydrocarbons, water and numerous process liquids

5. Spacer type coupling to permit liquid end disassembly without disturbing piping

6. Oversize heavy duty heat treated alloy steel shaft

7. Oil lubricated, heavy duty radial & thrust bearings

8. Spot electric welded case- and impeller-wear rings

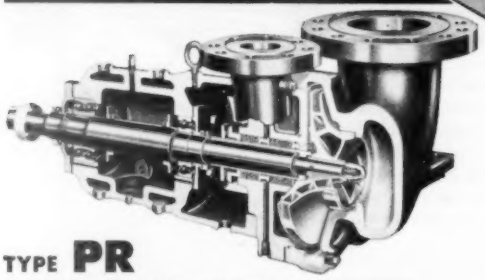
9. Capacity range: up to 1000 GPM

10. Operating heads: up to 625 feet; case pressures: to 400 PSIG

11. All types of drive; electric, steam turbine, stationary engine

12. Designed to operate with minimum NPSH

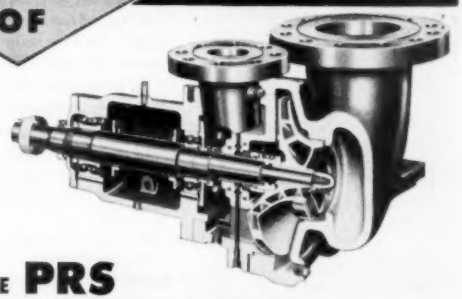
PACKING GLAND CONSTRUCTION *plus* THE CHOICE OF MECHANICAL SHAFT SEAL



TYPE **PR**

IMPROVED PACKING GLAND CONSTRUCTION

RECOMMENDED FOR TEMPERATURES TO 850° F.



TYPE **PRS**

DESIGNED FOR & WITH A SHAFT SEAL

RECOMMENDED FOR TEMPERATURES TO 250° F.

Select your pumps from these two proved Peerless designs built especially for refinery and process service. Remember: the Type PRS shaft sealed pump is designed with and for a mechanical shaft seal, not just adapted to it. Send coupon today for descriptive Type PR pump bulletin.

PEERLESS PUMPS

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION

Factories: Indianapolis 8, Indiana and Los Angeles 31, California
Offices: New York; Chicago; Indianapolis; Atlanta; St. Louis; Dallas, Lubbock and Plainview, Texas; Tulsa; Albuquerque; Phoenix; Fresno; Los Angeles.
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fmc FOOD MACHINERY AND CHEMICAL CORPORATION

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION
301 West Avenue 26, Los Angeles 31, California

Please send us a Bulletin on Type PR and PRS pumps

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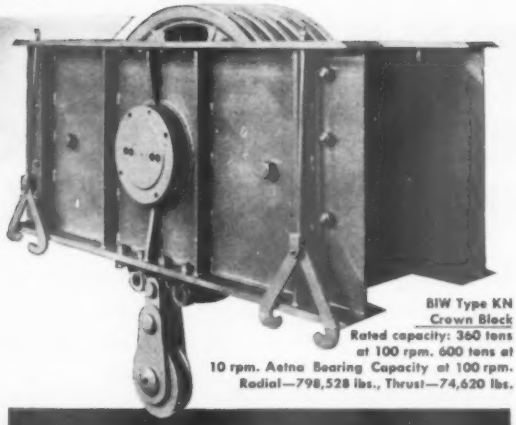
COMPANY_____

ADDRESS_____

CITY_____ STATE_____

O&GJ

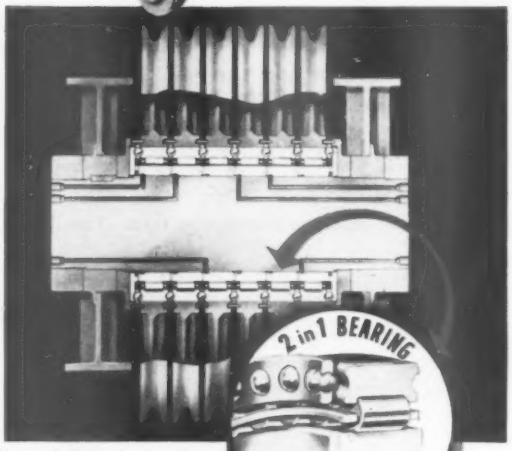
BIW Blocks
TEAMED WITH
Aetna
BEARINGS...



BIW Type KN Crown Block
Rated capacity: 360 tons at 100 rpm. 600 tons at 10 rpm. Aetna Bearing Capacity at 100 rpm. Radial—798,528 lbs., Thrust—74,620 lbs.

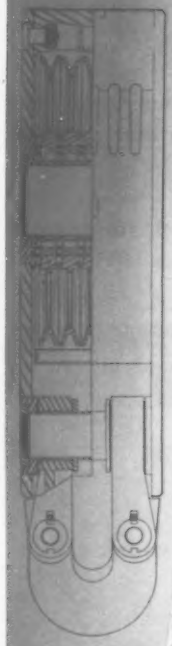
ANOTHER EXAMPLE OF HOW AETNA COOPERATIVE ENGINEERING PAYS OFF

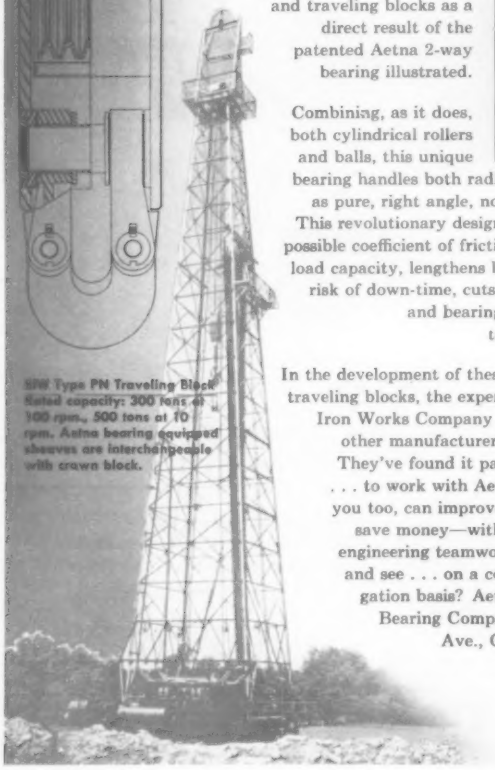
Compact, streamlined, weight-saving design and vastly superior functional utility—both are achieved in these Beaumont Crown and traveling blocks as a direct result of the patented Aetna 2-way bearing illustrated.



This efficient, compact design reduces width and weight, yet increases strength and durability of crown and traveling blocks—is adaptable to blocks with any number of sheaves.

Combining, as it does, both cylindrical rollers and balls, this unique bearing handles both radial and thrust loads as pure, right angle, non-interfering loads. This revolutionary design attains the lowest possible coefficient of friction, increases radial load capacity, lengthens bearing life, reduces risk of down-time, cuts block maintenance and bearing replacement costs to a new record low.





BIW Type PN Traveling Block Rated capacity: 300 tons at 100 rpm., 500 tons at 10 rpm. Aetna bearing equipped sheaves are interchangeable with crown block.

In the development of these better crown and traveling blocks, the experience of Beaumont Iron Works Company has been typical of other manufacturers the country over. They've found it pays . . . handsomely . . . to work with Aetna. Very possibly, you too, can improve your product and save money—with the help of Aetna engineering teamwork. Why not try it and see . . . on a confidential, no-obligation basis? Aetna Ball and Roller Bearing Company, 4600 Schubert Ave., Chicago 39, Illinois.

Standard and Special Ball Thrust Bearings • Angular Contact Ball Bearings • Special Roller Bearings • Ball Retainers • Hardened and Ground Washers • Sleeves • Bushings

This is Why the Nash is the Most Simple Compressor

It's the Nash!

There are no mechanical complications in a Nash Compressor. A single moving element, a round rotor, with shrouded blades, forming a series of buckets, revolves freely in an elliptical casing containing any low viscosity liquid. This liquid, carried with the rotor, follows the elliptical contour of the casing.

The moving liquid therefore recedes from the rotor buckets at the wide part of the ellipse, permitting the buckets to fill with gas from the stationary Inlet Ports. As the casing narrows, the liquid is forced back into the rotor buckets, compressing the gas, and delivering it through the fixed Outlet Ports.

Nash Compressors produce 75 lbs. pressure in a single stage, with capacities to 6 million cu. ft. per day in a single structure. Since compression is secured by an entirely different principle, gas pumping problems difficult with ordinary pumps are often handled easily in a Nash.

Nash simplicity means low maintenance cost, with original pump performance constant over long periods. Data on these pumps sent immediately on request

No internal wearing parts.

No valves, pistons, or vanes.

No internal lubrication.

Low maintenance cost.

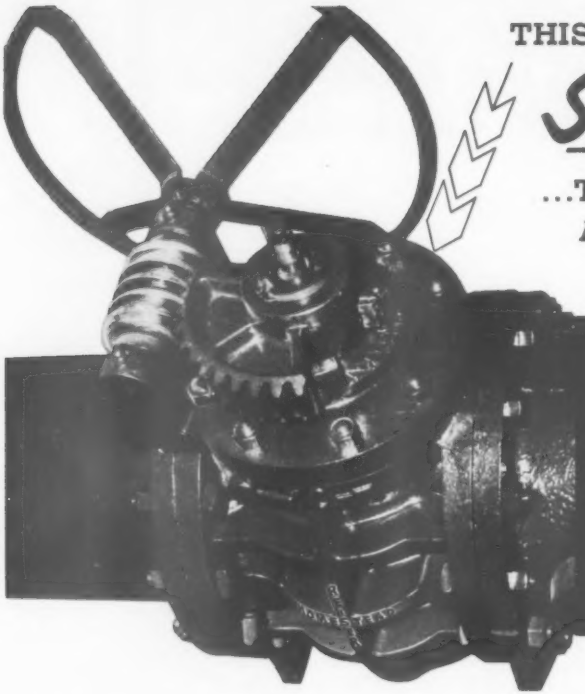
Saves floor space.

Desired delivery temperature automatically maintained.

Slugs of liquid entering pump will do no harm.

75 pounds in a single stage.

NASH ENGINEERING COMPANY
313 WILSON, SO. NORWALK, CONN.



THIS IS THE **VALVE** THAT

Seals itself

...THAT AUTOMATICALLY ADJUSTS FOR WEAR...

HOMESTEAD-REISER

Self-Seald...Lubricated

PLUG VALVE

A Homestead-Reiser *acts on its own* to maintain a *drop-tight seal* at all times. It continually and automatically—without manual assistance—adjusts itself to make up for wear as wear occurs.

Its ability to thus effectively seal itself is due to the wedge-action of its two-piece plug which, *under line pressure,* causes the finely finished plug surfaces to constantly press outward to form a perfect seal against the mirror-like bore of the body. A full lubricant seal surrounds the ports and top and bottom of the valve.

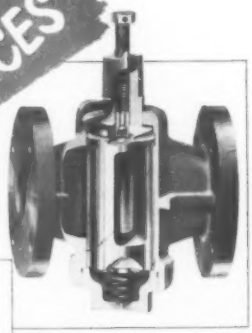
Extra-long, leakless service . . . more operations between lubrications—up to 22 times more by actual tests with other well-known lubricated plug valves . . . less maintenance and lower plant operating costs result from their use.

We can furnish them in semi-steel or cast-steel, 100% Port Area or Venturi, in sizes ½" to 14" for steam working pressures to 150 lbs., or oil—water—gas to 200 lbs.

Why not order today and prove them to your own satisfaction.

NOW! AT LOWER PRICES

Complete data and prices will be sent on request. Write today for VALVE REFERENCE BOOK No. 39. No obligation. For local distributor, see Yellow Pages of your Telephone Book.



Sectional View of Full Port Area Homestead-Reiser Valve

Available in Straight-Way—3-Way and 4-Way—screwed or flanged ends.

HOMESTEAD
VALVE MANUFACTURING COMPANY
Serving Since 1892

P. O. Box 403 **Coraopolis, Pa.**

Hard Going IS Easy Going

WITH MACK SIX-WHEELERS

It's really something to see—the way a Mack six-wheel truck shoulders a back-breaking load and without fuss or bother rolls effortlessly over the roughest terrain.

The reason why? Because only Mack six-wheel trucks have the unique advantage of Mack's time-saving, money-saving Balanced Bogie with exclusive Mack Power Divider.

With the Mack Power Divider you get positive traction under the most adverse conditions —through hub-deep mud, through slippery sand, or over rock-strewn uneven ground. Acting as a true differential, the Power Divider delivers torque between the two bogie axles and between the four driving wheels in proportion to wheel traction, thus eliminating useless wheel slippage and spinning.

The ability of Mack six-wheelers to keep going—even under conditions that stop other trucks cold — means greater profits for you through bigger payloads on faster, uninterrupted schedules. Write or call your nearest Mack branch or distributor for a factual study of your particular operation.

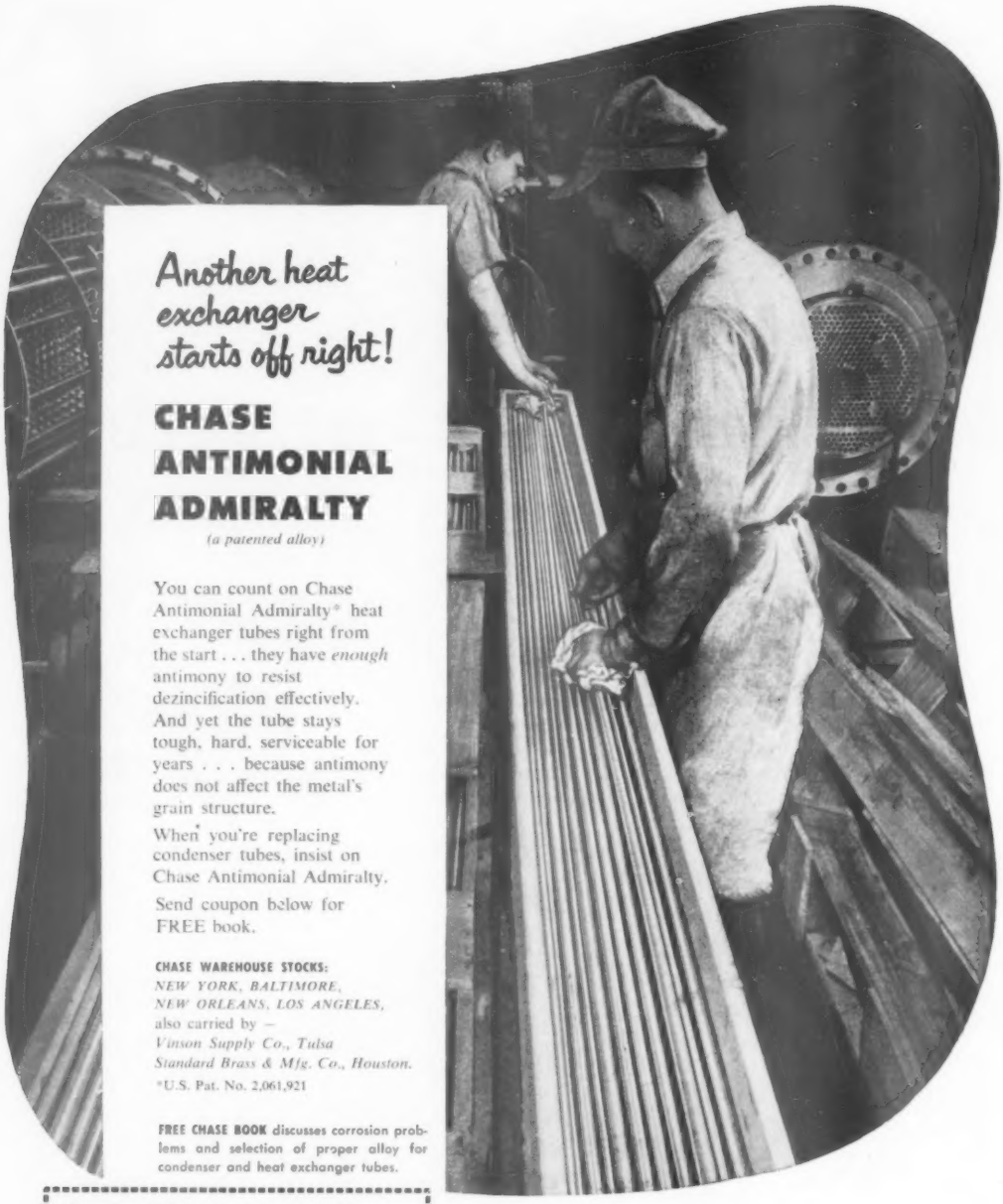
Mack Tandem Rear Axle Power Divider

Heavy loads and rough terrain in oil field service point up the ability of Mack six-wheel trucks to turn hard going into easy going. This Model LJSW is one of 19 Macks operated by C. A. Transporte La Guaira of Caracas, Venezuela.

Mack TRUCKS

outlast them all

Mack Trucks, Empire State Bldg., N. Y. 1, N. Y. Factory branches and distributors in all principal cities for service and parts. In Canada: Mack Trucks of Canada, Ltd.



Another heat exchanger starts off right!

CHASE ANTIMONIAL ADMIRALTY

(a patented alloy)

You can count on Chase Antimonial Admiralty* heat exchanger tubes right from the start . . . they have *enough* antimony to resist dezincification effectively. And yet the tube stays tough, hard, serviceable for years . . . because antimony does not affect the metal's grain structure.

When you're replacing condenser tubes, insist on Chase Antimonial Admiralty.

Send coupon below for FREE book.

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NEW YORK, BALTIMORE, NEW ORLEANS, LOS ANGELES, also carried by —
Vinson Supply Co., Tulsa
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FREE CHASE BOOK discusses corrosion problems and selection of proper alloy for condenser and heat exchanger tubes.

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Waterbury 20, Conn.

Please send me Free Book on Condenser and Heat Exchanger Tubes.

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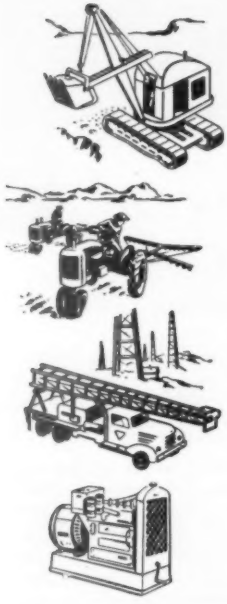
Cincinnati	Indianapolis	New Orleans	St. Louis	

THE CERTAINTY OF A SPARK

THE BUYWORD FOR DEPENDABLE IGNITION • • •



AMERICAN BOSCH MAGNETOS

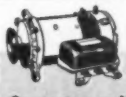
American Bosch Super Powered Magnetos give engines the constant, faultless spark that assures fast starts and prevents costly ignition tie-ups in drilling, producing, pipeline and refinery equipment. Add to these day-to-day, on-the-job advantages, more *years* of trouble-free ignition in the toughest oil industry service, and you'll appreciate why these power-packed Magnetos are in wide use as *original equipment* by many leading engine builders.

You can enjoy this persistent performance and economy of operation on ALL your present spark ignited engines with either high or low tension ignition systems. For, there's an American Bosch Magneto precisely engineered for all replacement needs . . . for the largest, heavy-duty engines in high or low tension applications, right down to the Magnetos required for the most modern, high-speed power units.

Moreover, there's a generous trade-in allowance for you on the old magneto you replace. Make American Bosch Magnetos your "buyword" for dependable ignition. Write for new 92-page Catalog, including application data. American Bosch Corporation, Springfield 7, Mass.

AMERICAN BOSCH

Automotive and Aviation Magnetos

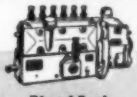

Generators and Regulators

Components for Aircraft Engines

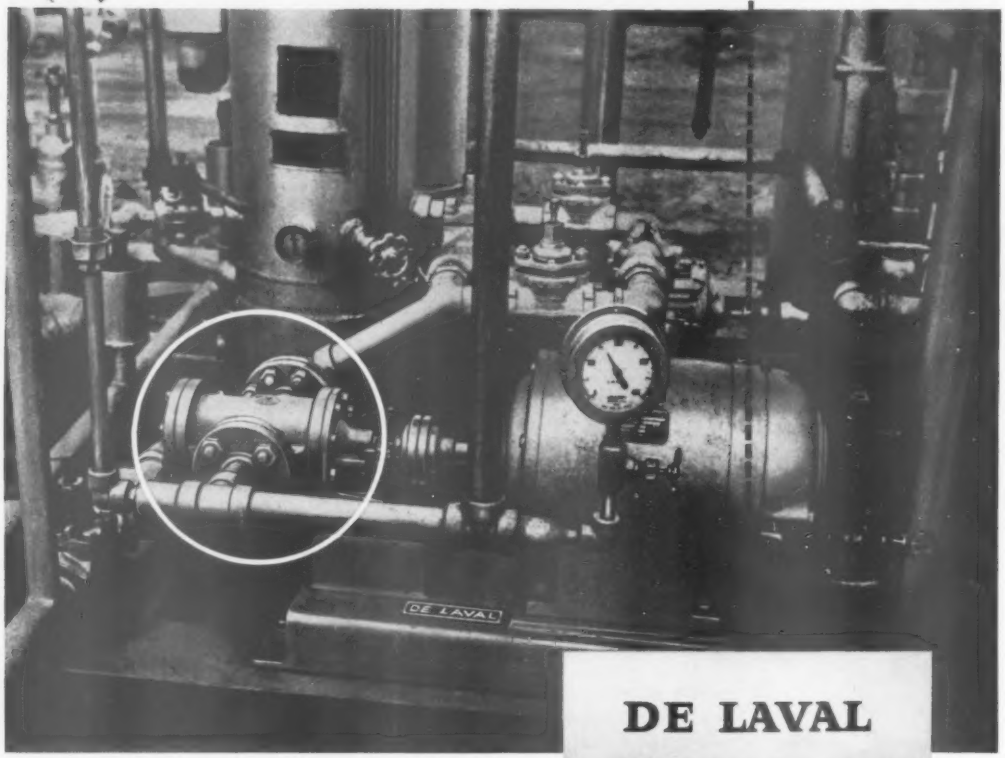
AMERICAN AB BOSCH

All Electric Windshield Wipers

Ignition Coils


Diesel Fuel Injection Equipment

Versatile pumps for refinery service



De Laval-IMO pump in service in midwest packaged gasoline plant.

DE LAVAL

IMO PUMPS

Today, De Laval-IMO rotary pumps are proving their versatility in dozens of refinery applications. These dependable pumps are being used in refineries and bulk plants to handle viscous fluids including fuel oils, heavy crude oils, lubricating oils and asphalt, as well as the lighter hydrocarbons. For example:

An eastern refinery installed an IMO to pump *viscous* oil at 550 psi. Performance was so satisfactory that three more IMO units were ordered within a few weeks.

A midwest refinery is using De Laval-IMO pumps to handle *asphalt* at 470F at 922 psi and *petrolatum* at 420F and 575 psi.

For a new tank field distribution system, another refinery has 58 direct-connected 1150 to 1750 rpm IMO pumps, handling various oils with viscosities up to 3600 SSU, capacities to 200 gpm and pressures to 150 psi.

The unique IMO design—*with only three moving parts* — assures long, trouble-free performance. IMO pumps are quiet, pulsation-free, compact and designed for direct-connected high-speed operation. Send for Bulletin LG showing wide range IMO line for capacities to 1,000 gpm at pressures to 500 psi and for capacities to 150 gpm at pressures to 1,500 psi.

DE LAVAL *IMO Pumps*

DE LAVAL STEAM TURBINE COMPANY
810 Nottingham Way, Trenton 2, New Jersey

Remember, all the "extras" come with it

DEEP PENETRATION
is, of course, the big reason you order shaped-charge perforating. And you get that deep penetration — *proved* penetration — with KONESHOT. But, just as important, you get *all* the "extras" with it!

ACCURATE DEPTH MEASUREMENT
Pretty important "extra," isn't it? Lane-Wells depth measurement accuracy is acknowledged to be the standard of the industry.

SAFETY
Another important extra. Lane-Wells safety-engineered equipment and procedures give maximum safety to well and to personnel, as shown by Lane-Wells' unequaled safety record.

ON-TIME SERVICE
is a big factor in holding down your costs. Lane-Wells 69 branches are located to give quick, dependable service around the clock to every active drilling area.

EXPERIENCE
is just a short way of saying "Knowing what to do and how to do it quickly and do it right." Lane-Wells has that experience, gained in more than 175,000 perforating jobs in every oil field in the country.

LANE WELLS

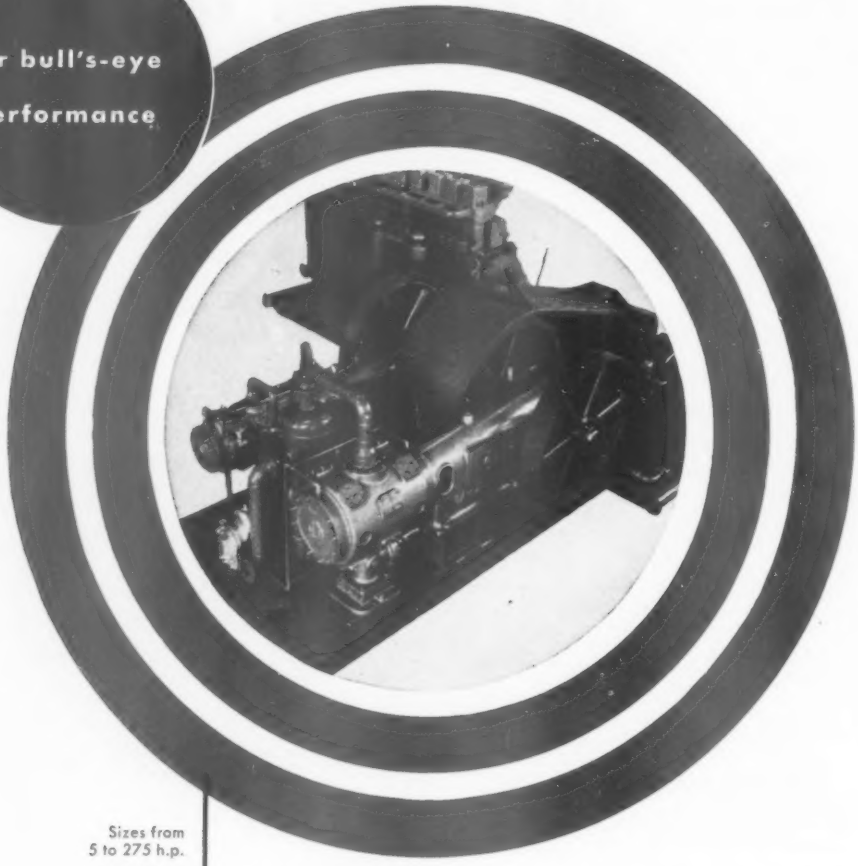
General Offices, Export Office, Plant • 5610 So. Soto St., Los Angeles 58

Tomorrow's Tools Today!

LOS ANGELES • HOUSTON • OKLAHOMA CITY • LANE-WELLS CANADIAN CO. IN CANADA • PETRO-TECH SERVICE CO. IN VENEZUELA

AK-511

for bull's-eye performance



Sizes from 5 to 275 h.p.

portable or stationary models

single stage or two-stage units

vertical or horizontal compressors

electric motor or gas engine drive

Dallas • Houston • Tulsa • St. Louis
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Continental Supply Co., Continental Bldg., Dallas, Texas
Export Division: 30 Rockefeller Plaza, New York, N. Y.

Republic Supply Co., (Of Calif.), 2600 S. Eastland Ave., Los Angeles, Calif.

choose GARDNER-DENVER booster compressors

You'll hit a high score in efficiency and dependability when you install Gardner-Denver Compressors for booster service, re-pressuring or air-gas lift. Tailored to your field conditions, they're available in a wide range of capacities and pressure ratings. They're complete, compact units—easily trucked in—ready to hook up and start up.

Call your nearest Gardner-Denver field engineer for complete details, or write us.

SINCE 1859

GARDNER-DENVER

Quincy, Illinois
In Canada: Gardner-Denver Company (Canada), Ltd., Toronto, Ontario

THE QUALITY LEADER IN COMPRESSORS, PUMPS AND ROCK DRILLS

Check List

for selecting a Piping Contractor

Listed below are a number of important factors that should be taken into account whenever you select a piping contractor. If any of these are overlooked, you are not buying your piping construction to best advantage.

☐ **EXTENSIVE SIMILAR EXPERIENCE** • Is the contractor thoroughly experienced on your type of work? Problems are always more readily solved when they have been met before.

☐ **MODERN FABRICATING PLANTS** • Fully equipped plants staffed by piping experts mean practical piping subassemblies that are correctly planned and prefabricated to simplify and expedite field erection.

☐ **PROGRESSIVE ORGANIZATION** • You want a contractor who keeps abreast of new piping developments. Piping research on a continuous basis should be his policy.

☐ **CONVENIENT LOCATION** • A fabricating plant near enough to give you quick service is of prime importance. Convenient location also improves overall supervision of the job.

☐ **SUPERIOR FIELD FACILITIES** • A job of any size needs a resident superintendent with a permanent staff of supervising erectors. Welders should be qualified on your materials.

☐ **PLUS SERVICES** • The experienced contractor often can make suggestions that result in improved piping design and savings in time and money.

4586

You can check all these when you select MIDWEST

MIDWEST PIPING SERVICE IS NATION-WIDE

4 Plants Are Better Than 1

PIPING FABRICATORS AND CONTRACTORS

MIDWEST PIPING & SUPPLY CO., INC.
Main Office: 1450 South Second Street, St. Louis 4, Mo.
Plants: St. Louis, Passaic, Los Angeles and Boston
Sales Offices: New York 7—90 Church St. • Chicago 3—79 West Monroe St.
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Compressor Division
WILSON
SUPPLY
CO
HOUSTON, TEXAS

If your requirements for Gas Lifting or Booster work calls for 85 H. P., 150 H. P. or 500 H. P.– you can get best results with an installation of Wilson Supply–Ingersoll-Rand "Packaged" Portable Compressors.

The "Know How" of the Compressor Division of Wilson Supply Company in fabricating these units means dollars saved to the purchaser in long life and trouble free performance.

•

Contact your nearest Wilson Supply Store or write "Compressor Division," Wilson Supply Company, P. O. Drawer 19, Houston, Texas, for detailed information, and quotations. Please give suction and discharge pressure and volume to be handled.

•

Branch Stores

TEXAS: Alice, Corpus Christi, Victoria, Bay City, Columbus, Barbers Hill, Liberty, Beaumont, Kilgore, Monahans. LOUISIANA: Lake Charles, New Iberia, Houma, Harvey, Shreveport.

SALES OFFICES

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Dallas, Texas
New Orleans, La.
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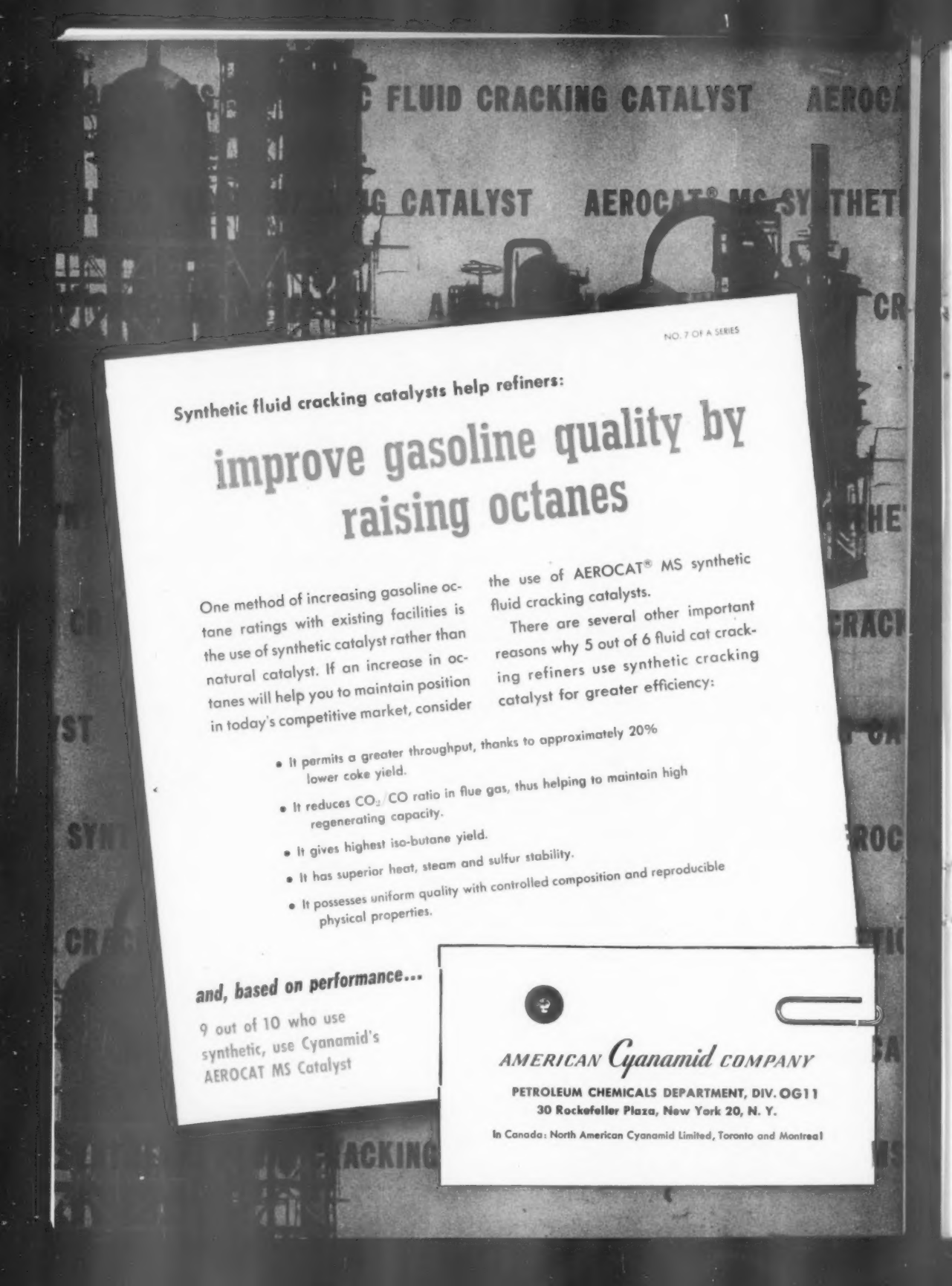

NO. 7 OF A SERIES

Synthetic fluid cracking catalysts help refiners:

improve gasoline quality by raising octanes

One method of increasing gasoline octane ratings with existing facilities is the use of synthetic catalyst rather than natural catalyst. If an increase in octanes will help you to maintain position in today's competitive market, consider the use of AEROCAT® MS synthetic fluid cracking catalysts.

There are several other important reasons why 5 out of 6 fluid cat cracking refiners use synthetic cracking catalyst for greater efficiency:

- It permits a greater throughput, thanks to approximately 20% lower coke yield.
- It reduces CO_2/CO ratio in flue gas, thus helping to maintain high regenerating capacity.
- It gives highest iso-butane yield.
- It has superior heat, steam and sulfur stability.
- It possesses uniform quality with controlled composition and reproducible physical properties.

and, based on performance...

9 out of 10 who use synthetic, use Cyanamid's AEROCAT MS Catalyst

AMERICAN Cyanamid COMPANY

PETROLEUM CHEMICALS DEPARTMENT, DIV. OG11
30 Rockefeller Plaza, New York 20, N. Y.

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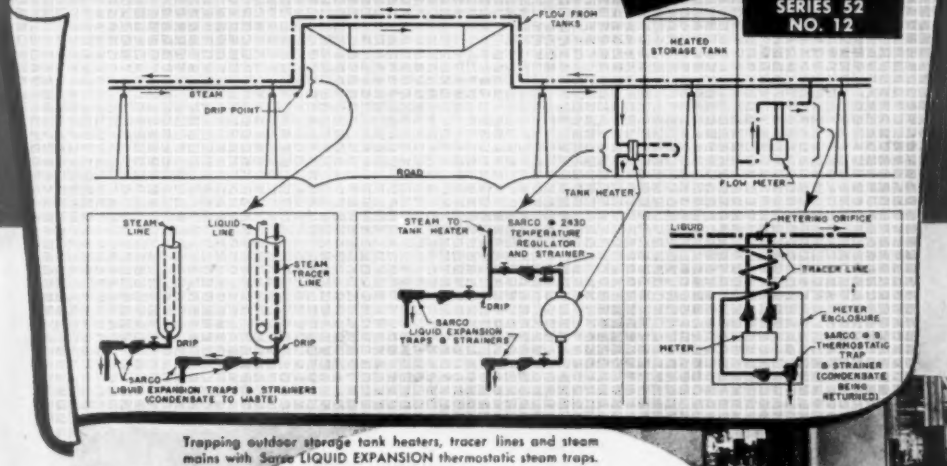
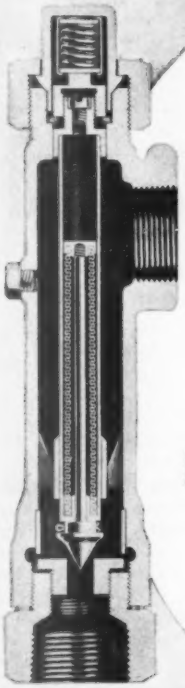
Steam Trapping

OUTDOORS

SERIES 52
NO. 12



Trapping outdoor storage tank heaters, tracer lines and steam mains with Sarco LIQUID EXPANSION thermostatic steam traps.



Sarco No. 871 LIQUID EXPANSION thermostatic steam trap for outdoor applications. Discharges condensate in a continuous stream at temperatures always below 212°F.

Have you the problem of removing air and condensate from outdoor storage tank heaters, tracer lines and mains?

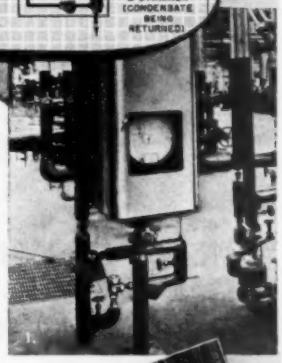
Sarco, and Sarco alone offers you a special LIQUID EXPANSION thermostatic steam trap designed especially for this type of installation.

The Sarco LIQUID EXPANSION thermostatic steam trap has these advantages:

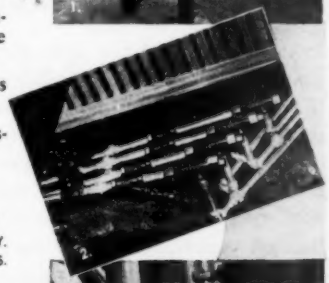
1. Needs no protection against freeze ups.
2. Discharges condensate at adjustable temperatures below 212° F., making it possible to use some of the sensible heat of the condensate.
3. Small size, light weight, large capacity — as easy to install as a pipe elbow.
4. Not affected by water-hammer, vibration, pressure pulsations or superheat.
5. And just as effective indoors too.

Write for new Bulletin 260-4, free for the asking.

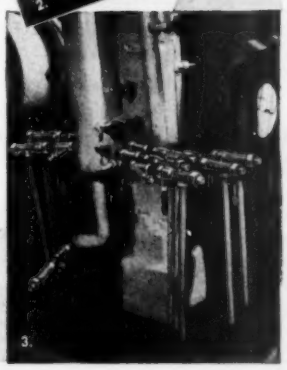
SARCO COMPANY, INC., Empire State Bldg., New York 1, N. Y.
SARCO CANADA LTD., TORONTO 8, ONT. REPRESENTED IN PRINCIPAL CITIES.



1. Removing air and condensate from coil heaters in flow meter cabinets with Sarco No. 9 balanced pressure thermostatic steam traps.



2. Steam jacketed asphalt lines and a jacketed pump drained by Sarco No. 871 LIQUID EXPANSION steam traps. (Globe Roofing Products Co. Whiting, Ind.)



3. Sarco No. 871 LIQUID EXPANSION Steam Traps draining air and condensate from steam tracing lines.

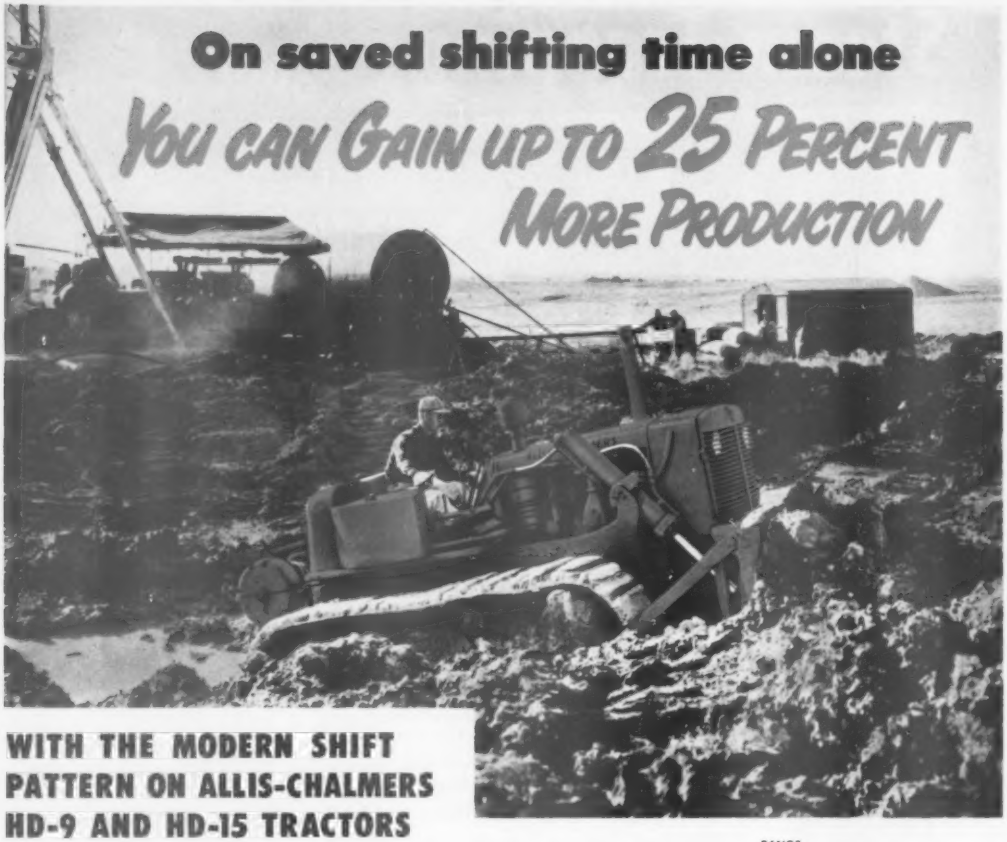
SARCO saves steam

improves product quality and output

416

On saved shifting time alone

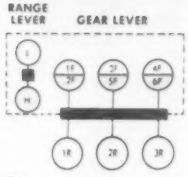
YOU CAN GAIN UP TO 25 PERCENT MORE PRODUCTION



WITH THE MODERN SHIFT PATTERN ON ALLIS-CHALMERS HD-9 AND HD-15 TRACTORS

It takes just half the time and effort to change from low forward to fast reverse with the Allis-Chalmers HD-9 and HD-15 transmission. This shifting time saved becomes production time gained on bulldozing and other jobs calling for a short forward-backward cycle. For example, job studies prove that on backfilling, pusher work, working around large excavators, digging and loading with front-end shovels — other jobs where frequent shifts are required — you can make five passes in the time usually required to make four... actually increase production up to 25 percent.

Here's how it works



You go from any forward to any reverse speed with one simple shift of the gear lever. The only time you touch the range lever is to select the forward range you want for the job to be done — just set it and forget it.

The constant-mesh Allis-Chalmers transmission makes shifting smooth and effortless . . . without gear clashing. And it's so easy that the operator can *always* take advantage of high-speed reverse.

This exclusive shift pattern, together with all-steel welded construction, unit assembly, 1,000-hour lubrication, are just a few of the reasons you get more work done with the new *designed-for-your-job* Allis-Chalmers tractors.

ALLIS-CHALMERS

TRACTOR DIVISION • MILWAUKEE 1, U. S. A.

Oil Field Emporium

most business is done at the well

There are snakes in some parts of the oil country and there the National Supply Stores carry snake-bite kits. Whether it's a flashlight bulb or a set of V-belts, a pipe wrench or pipe dope, it's carried in stock at the National Supply Store awaiting your convenience.

In bad weather or good, National's field representatives make their calls at the drilling sites and the wells, maintain the daily contacts with oil field operations and problems so that a complete inventory of essential equipment can be kept in readiness at the nearby National Supply Store.

As the petroleum industry grew, National's supply service expanded with it. Today, more than a hundred stores cover the oil fields of the United States and Canada, while a world-wide export organization provides a supply service overseas.

It will be worth your while to drop in at the National Supply Store to see for yourself why you always find everything that's new and everything that's standard in oil field supplies at National.

THE NATIONAL SUPPLY COMPANY

Pittsburgh 30, Pennsylvania

NSCO

A single source for

drilling and production equipment . . .

materials for preventive maintenance . . .

safety and operating supplies

THE NATIONAL SUPPLY STORE

The stock list of a National Supply Store includes thousands of items ranging from hand tools to major equipment—a complete and carefully controlled inventory of machinery and supplies to fit the requirements of its service area.

Actually, some stores will carry 12,000 or more items of such broad scope that they can be only loosely grouped in the categories of—

- Drilling and Production Equipment
- Materials for Preventive Maintenance
- Safety and Operating Supplies

But they're all there in the shelves, racks, bins and open storage areas—ready for inspection and selection, ready for use at the well site wherever and whenever they're needed.

That makes purchasing from the National Supply Store such a simple matter—everything you need from a single source . . .

THE NATIONAL SUPPLY COMPANY

Pittsburgh 30, Pennsylvania

DIVISION OFFICES: Casper • Ft. Worth • Houston • Pittsburgh
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CANADA: The National Supply Company, Ltd., 702 Barron Bldg., 610 Eighth Ave., West, Calgary, Alberta

EXPORT: 600 Fifth Ave., New York 20, N.Y., U.S.A.; River Plate House, 12 South Place, London, E.C. 2

NATIONAL BLUE PRODUCTS

..take sucker rods as a typical example—

National Sucker Rods

for every well condition—

National Sucker Rods were developed by engineers long familiar with the problems of rod pumping, pumping units, well characteristics, and downwell equipment. They are typical products in the completely integrated line of National production equipment.

Of course, the proper grades of National Sucker Rods are carried in stock at National Supply Stores in the United States and Canada along with those hundreds of other types of production equipment. They are, therefore, a typical example of the completeness of the supply service rendered by the National Supply Stores.

It's time to get better acquainted with all of the many lines of oilfield equipment available at the National Store.

NATIONAL BLUE PRODUCTS

THE NATIONAL SUPPLY COMPANY
Pittsburgh 30, Pennsylvania

DIVISION OFFICES: Casper • Ft. Worth • Houston • Pittsburgh Tulsa • Torrance

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INDUSTRY'S ALL-TIME FAVORITE FOR LONG RANGE *Economy*

JENKINS
Fig. 106-A
Renewable Composition Disc
BRONZE
GLOBE VALVE
150 lbs. Steam
200 lbs. O.W.G.

Take a Jenkins Fig. 106-A apart. It's easy to see why it is industry's all-time favorite. Note the liberal dimensions of body and bonnet casting — the heavy, manganese bronze spindle, with more strong threads in contact with the bonnet, regardless of spindle position. See how the slip-on, stay-on disc holder fully protects the edge of the disc, prevents creeping, flaking, or cracking.

Every part, from perfect grip, heatproof handwheel to pipe ends, reflects the designing skill of Jenkins valve *specialists.* There's a good reason. Jenkins Bros. introduced the *first* renewable composition disc valve, — is today the only manufacturer of both valves *and* discs.

Fig. 106-A not only looks better — it proves out better in performance. In any comparison, its long life, low upkeep record has never been surpassed. That is the true measure of valve cost — and it is the reason why industry's shrewdest buyers will settle for nothing less than Fig. 106-A quality.

JENKINS VALVES
LOOK FOR THE DIAMOND MARK
SINCE 1864 TRADE JENKINS MARK
Jenkins Bros.

GET THIS FOLDER — Gives details of Fig. 106-A design, and "family" interchangeability. Ask your Jenkins Distributor for Form 189-A, or write Jenkins Bros., 100 Park Ave., New York 17.

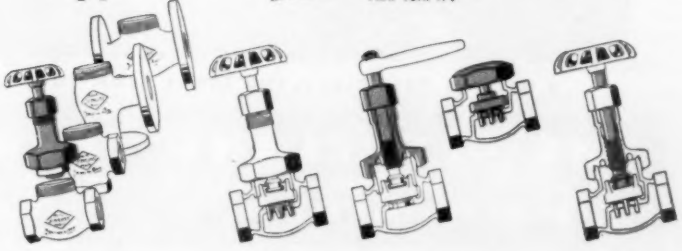

Fig. 106-A "Family" Interchangeability meets 90% of your valve needs with a small inventory of parts. Start with the standard Fig. 106-A. Trimming is interchangeable in Globe or Angle body, screwed or flanged. With a few parts, quickly-assembled combinations provide a Lift Check, a Spring-loaded Check, and valves for Stop and Check, Quick-opening, or Throttling service.

CLEVELANDS

for steady "ON SCHEDULE" production

in all kinds of going

● Pipeliners the world over know from experience that CLEVELANDS deliver trench *on schedule* no matter how tough the digging. CLEVELAND dependability is the result of a *perfectly balanced combination* of practical pipeline trencher features:

BUILT TOUGH. Modern, proved design and tough alloy steels strip off all dead weight, make every CLEVELAND pound a working pound.

LONG LIVED. Quality construction keeps CLEVELANDS "on the line" delivering "on schedule" peak production day in and day out, year after year.

UNIT DESIGN. All major components are "packaged" and easily accessible, permitting speedy, on-the-job repairs and wear parts replacement.

ENGINEERED FOR THE JOB. Properly powered —wide range of usable digging wheel and crawler speed *combinations*—full wide crawler maneuverability and low ground bearing pressure—low center of gravity—accurately balanced for maximum digging efficiency in all soil and terrains.

● GET THE FULL CLEVELAND STORY FROM YOUR LOCAL DISTRIBUTOR

THE CLEVELAND TRENCHER CO.

Pioneer of the Modern Trencher

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WHY GASO PUMPS ARE FIRST IN THE FAVOR OF PIPELINE MEN

Series 2600—largest in the Gaso line. Designed to pump oil or water through long lines at pressures ranging from 475 to 1500 pounds per square inch. Rated capacity, 275 to 1000 barrels per hour.

Less Cost Per Barrel...

That's what counts in choosing pumps—the net cost per barrel of fluid pumped. The life of the pump, its operating cost and maintenance expense must all be considered in arriving at this figure. Take it from any veteran pipeline man—no pump in any field has a better record of economical performance than Gaso Pumps. We have made them that way for over 37 years. May we send you a copy of our latest catalog?

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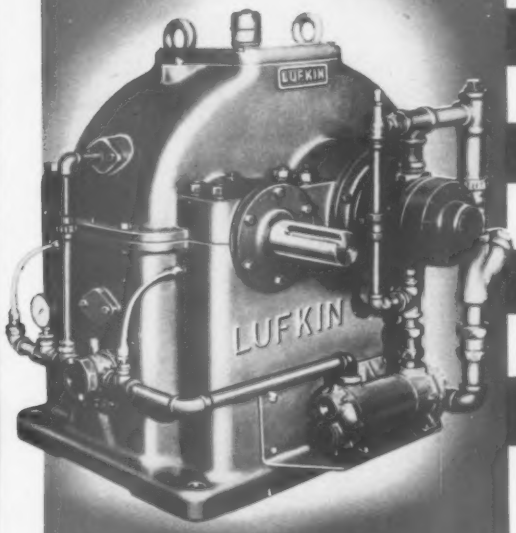
GASO PUMPS

for every oil industry need

Lufkin HERRINGBONE GEAR SPEED REDUCERS AND INCREASERS



LUFKIN, TYPE N "HIGH SPEED"

ANY SIZE
3 TO 2000 H. P.

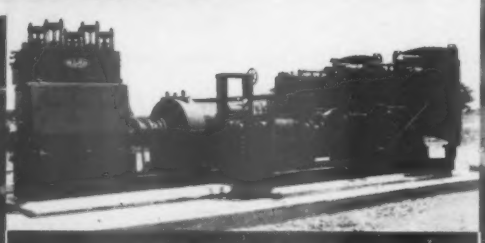
ANY SPEED
0 TO 12,000 R. P. M.

ANY RATIO
1 TO 1 TO 70 TO 1

ANY JOB
WHERE SPEED IS REDUCED OR INCREASED . . . . . .

Eighty Different Sizes From Which To Choose

PIPELINE PUMP



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ALSO SPIRAL BEVEL REDUCERS FOR COOLING TOWERS

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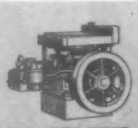
Lufkin Equipment in CANADA is handled by
THE LUFKIN MACHINE CO., LTD. 14321 108th Avenue, Edmonton, Alberta, Canada.

LUFKIN IS CELEBRATING ITS 50TH ANNIVERSARY THIS YEAR

LUFKIN PUMPING UNITS



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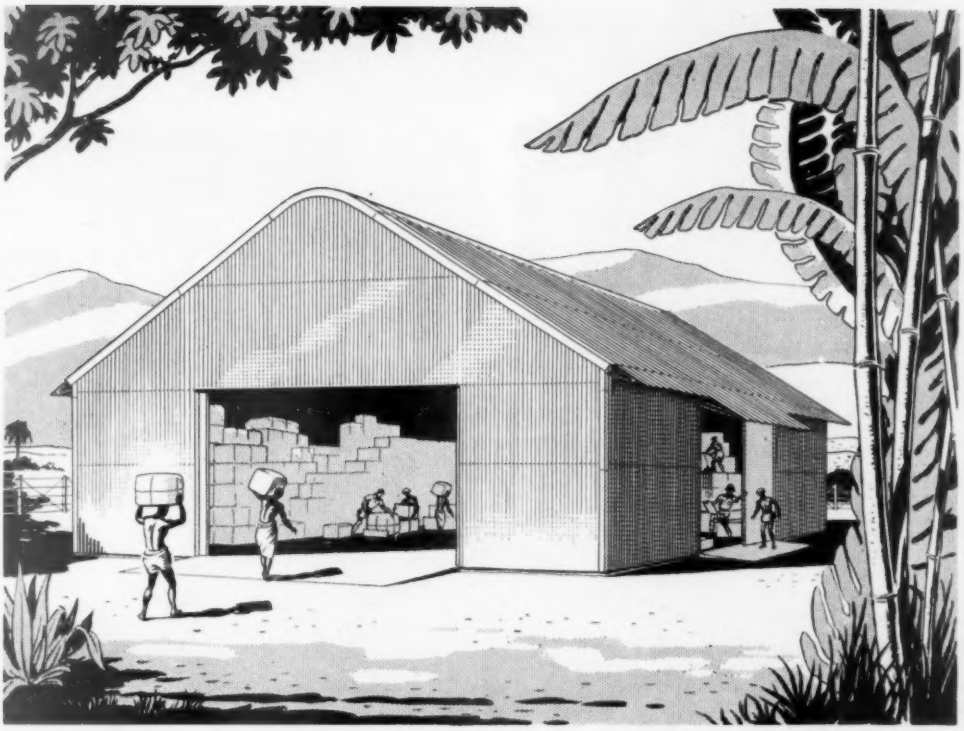
LUFKIN OIL FIELD AND INDUSTRIAL TRUCK TRAILERS

INDUSTRIAL SPEED REDUCERS AND INCREASERS

DIVISION LUFKIN FOUNDRY & MACHINE COMPANY INDUSTRIAL, MILL AND AUTOMOTIVE SUPPLIES



'Arcon' built—*and a 'special' for Space!*

(1) *A labour force of eight unskilled men can easily put up the framework of an 'Arcon' 3-bay Storage Building in approximately 27 hours.*

(2) *The walls and roof are made of durable, corrugated asbestos cement sheeting, which is easy to fit. 'Arcon' doors and windows can be inserted where needed; transparent corrugated sheets ("Perspex") may also be fitted as desired.*

(3) *This is the finished 'Arcon' Storage Building; its form of construction makes it easy to extend or modify to meet changing requirements.*

'Arcon' Storage Buildings are proving their worth all over the world. A case in point is the use of such a building for Customs and loading sheds in harbour development in Australia. Point by point the 'Arcon' Structure suited all requirements perfectly; it could be erected at short notice by unskilled men with the minimum of specialist supervision; it provided ample space which could be made larger still, if necessary, by simply adding extra bays on the principle of 'Arcon' flexible planning; and finally, the finished 'Arcon' Storage Building would be strong, fireproof, and indeed almost indestructible equally suitable for a warehouse, machine-shop, or for meeting a variety of accommodational needs. We have also supplied this type of building for use as garages in Burma and the Sudan; whilst a further successful application has been proved in West Africa, where the 'Arcon' Storage Building was supplied to construct a native market.

We will gladly send you our free brochure giving you full details of the 'Arcon' Storage Building. You will be able to see clearly how well 'Arcon' can answer *your* needs.

'ARCON' *Structures*

Write to:

TAYLOR WOODROW (BUILDING EXPORTS) LTD

41 WELBECK STREET · LONDON W.1 · ENGLAND

The only evidence of Lummus at this stage of the project is a team of 'dozers doing initial clearing. But soon it will be a completely-integrated petroleum refinery . . . or a modern chemical plant . . . or petroleum chemical units employing the newest and best processing concepts.

Meanwhile, the earth-movers are prophetic. They signal the application of Lummus' complete one-contract, one-responsibility engineering service from initial studies through acceptance run. And the trademark they wear means that *every* Lummus man who has a hand in the project has a strong and steady desire to make *this* the best job ever turned out by the company.

Isn't this the spirit, quality and depth of technical talent you'd like to engage for your next project? You'll find it in abundance at Lummus. If you use it, you put into force the strongest guarantee of a modern, flexible, efficient, profitable plant.

THE LUMMUS COMPANY

385 MADISON AVENUE, NEW YORK 17, N. Y.

HOUSTON • CHICAGO • LONDON • PARIS • CARACAS

DESIGNING ENGINEERS AND CONSTRUCTORS FOR THE PETROLEUM AND CHEMICAL INDUSTRIES

Announcing

THE IMPROVED STANDARD AXELSON LONG STROKE PUMPING UNIT

The profit producing advantages of the Axelson Hydraulic Long Stroke Unit are now intensified by improvements in design and construction. Now available to the petroleum operator, is the Improved Standard Model incorporating the following:

- Self-aligning, self-lubricating, spring loaded stuffing box eliminates the possibility of over tightening and burning the packing.
- Engineered fluid flow pattern in reverse valve mechanism provides minimum turbulence and reduces fluid friction losses.
- Unit is integral and requires no outside connections other than fuel lines.
- Base tripod is wider and higher, allowing a higher break out point and ample room for servicing well-head.
- Scavenger tank is integral with main base and has been appreciably increased in volume for storage capacity.
- Main control valve is actuated hydraulically through a centrally located control panel.
- "O" ring seals are used extensively to replace gaskets thereby assuring drip-proof joints in cylinder sections, etc.
- Where possible, welded and flanged pipe connections have replaced threaded joints in pressure lines.
- Spherical tank of sufficient capacity has replaced the vertical fluid tank and eliminated the horizontal balance tank thus reducing foundation requirements and hence installation costs.
- Reversals at top and bottom are actuated hydraulically through a unitized pilot and reverse valve assembly, permitting stroke length adjustment at both ends of cycle.
- Shorter main drive belt centers, providing less drive h.p. loss.

An Axelson engineer is at your service for discussion of any specific pumping problem.

Axelson

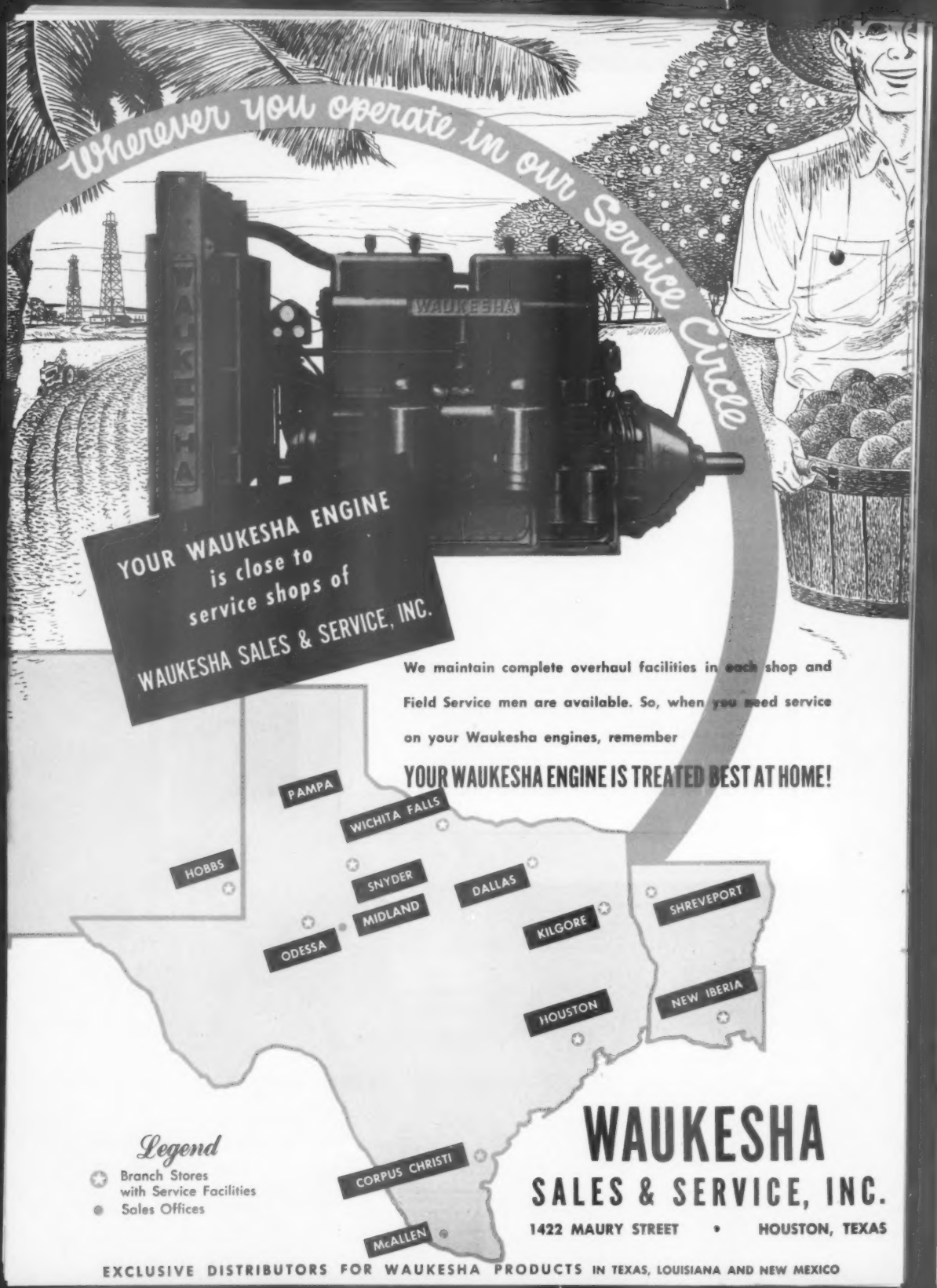
PETROLEUM PUMPING EQUIPMENT

OUR 60th YEAR

CHOSEN FIRST...TO LAST!

THERE IS NO ECONOMICAL SUBSTITUTE FOR QUALITY

AXELSON MANUFACTURING CO. • 6160 SOUTH BOYLE AVENUE • P.O. BOX NO. 15035, LOS ANGELES 58, CALIFORNIA


Wherever you operate in our Service Circle
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YOUR WAUKESHA ENGINE
is close to
service shops of
WAUKESHA SALES & SERVICE, INC.
We maintain complete overhaul facilities in each shop and Field Service men are available. So, when you need service on your Waukesha engines, remember
YOUR WAUKESHA ENGINE IS TREATED BEST AT HOME!
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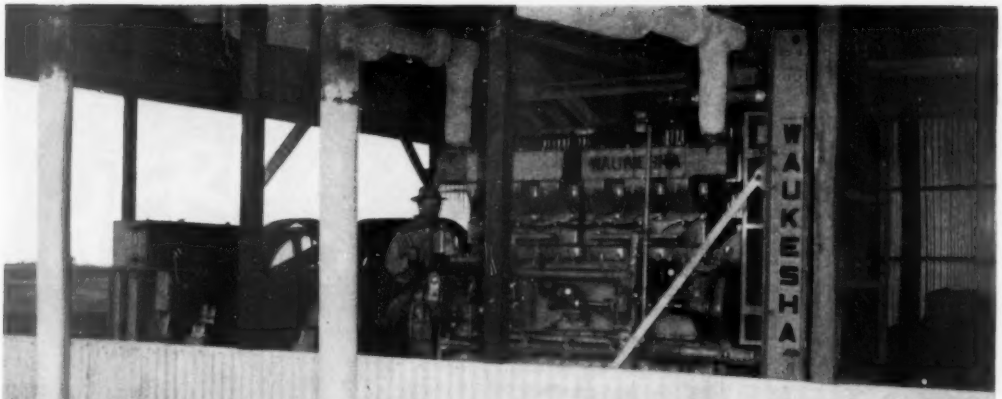
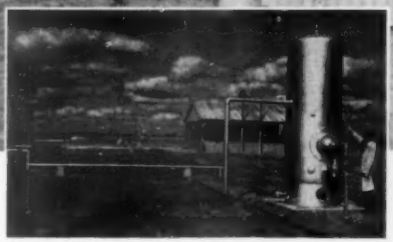


"never junked a WAUKESHA!"



Lenoir M. Josey, Inc., of Houston, saves gas with closed gas lift on 5 wells in Hutchins-Kubela field, Wharton County, near El Campo, Texas.

A Waukesha 6-LROU, 6-cyl., 8½ x 8½, 2894 cu. in. unit powers pump in compressor plant shown. Inlet gas scrubber (*left*) surge "bottles" (*right*).

The new Model LROU Waukesha which you recently installed in our gas lift plant at El Campo, just "fills the bill". It has sufficient power to take care of the heavy loads when the suction is flooded with gas lift gas from the wells, yet it runs smooth during the periods when the suction is low and the load is off.

This is the third installation of Waukesha in our campaign to eliminate flare gas on leases in Texas. During the past year, we have spent nearly a quarter of a million dollars in conservation practices and Waukesha Engines have figured in every installation. This was prompted by our records showing long service life and low costs of upkeep on our Waukesha installations.

We have 38 Waukeshas of various models and ages on our producing leases. Many of these are 10 to 15 years old and we have never junked a Waukesha Engine. For this reason, we have standardized as near as possible on Waukesha Engines.

W. D. Carleton, Prod. Supt.
LENOIR M. JOSEY, INC.

Send for Waukesha Bulletin No. 1560

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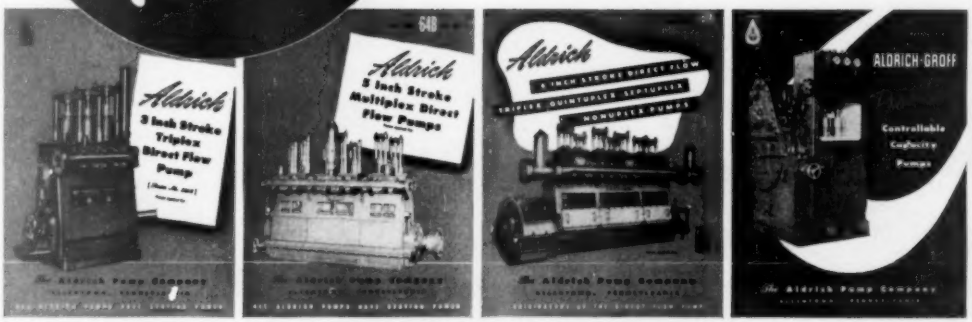
Give us an opportunity to say YES

HERE'S HELP

For Men Who Specify, Buy or Use Reciprocating Pumps



☐ 10 to 50 hp ☐ 50 to 275 hp ☐ 300 to 900 hp ☐ 5 to 125 hp

Tear out this page NOW and send for these Aldrich Data Sheets

These 2-color data sheets give full details of design and construction, including dimension and sectional drawings, performance data and pump specifications.

Aldrich Pump Applications

. . . include water flooding, salt water disposal, lean oil service; crude, gathering and product lines, bottom hole pump service, pumping liquid hydrocarbons.

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Be sure to fill in your name and address. Then mail this page to: The Aldrich Pump Company, Allentown, Pa.

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From the massive mill that pierces the white-hot billet, through every step in processing, to final checks and tests in the laboratory, Globe processes are *specialized* . . . specialized to give you high quality — uniformity of diameter, concentricity, wall thickness.

Globe has *specialized* in the research, engineering, and manufacture of steel tubes for more than 30 years. Advanced machinery and methods — rigid inspection and quality controls — characterize all production operations from billet to finished tube. Write for the Globe general catalog.

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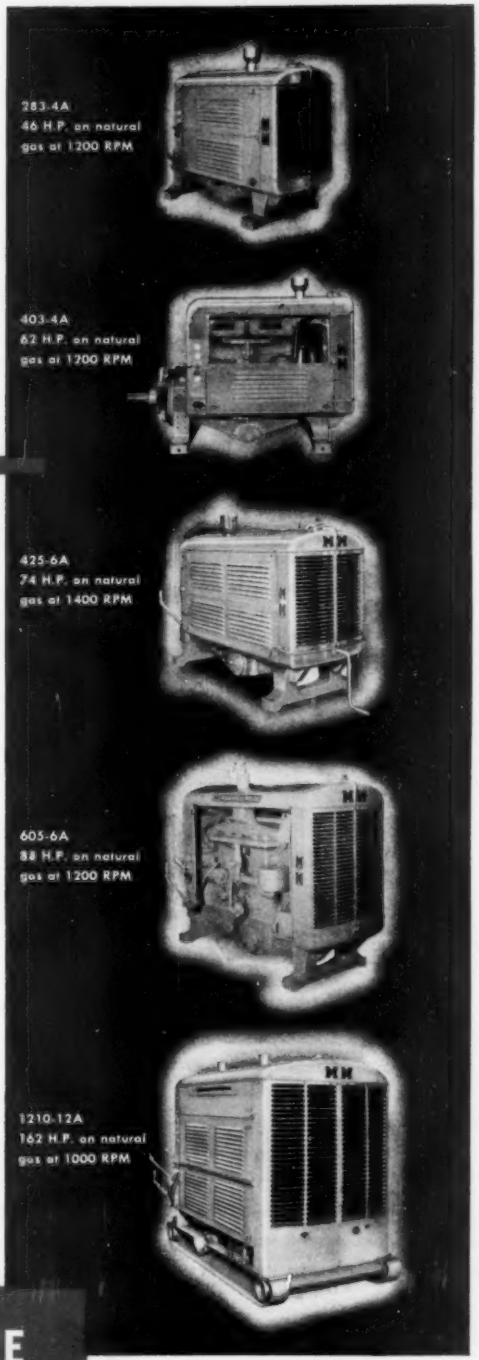
to fit every oilfield job!

*R*ugged parts design that gives you ***longer*** engine life, continuous performance . . . slow-speed operation with a *reserve* of *work-power*—these are the things you get with MM Power Units. ***But that's not the whole story!*** MM owners and users will tell you that MM Power Units are ***quality*** engineered to deliver ***low-cost*** power.

These advantages have helped to build MM's enviable reputation: Accurately controlled cooling of the high-turbulence combustion chambers; positive lubrication and water jacketted base pan that maintains constant oil temperature to prevent formation of engine-wearing sludge; metered vacuum crankcase ventilation; automatic cut-out on cooling and lubricating systems. These features have helped, but what is more important are the materials and workmanship of construction, the fine tolerances, the larger bearing surfaces . . . briefly put, it's the *integrity* that's built into MM!

Your dollars can purchase no more. Can you afford to invest in less?


283-4A
46 H.P. on natural gas at 1200 RPM
403-4A
62 H.P. on natural gas at 1200 RPM
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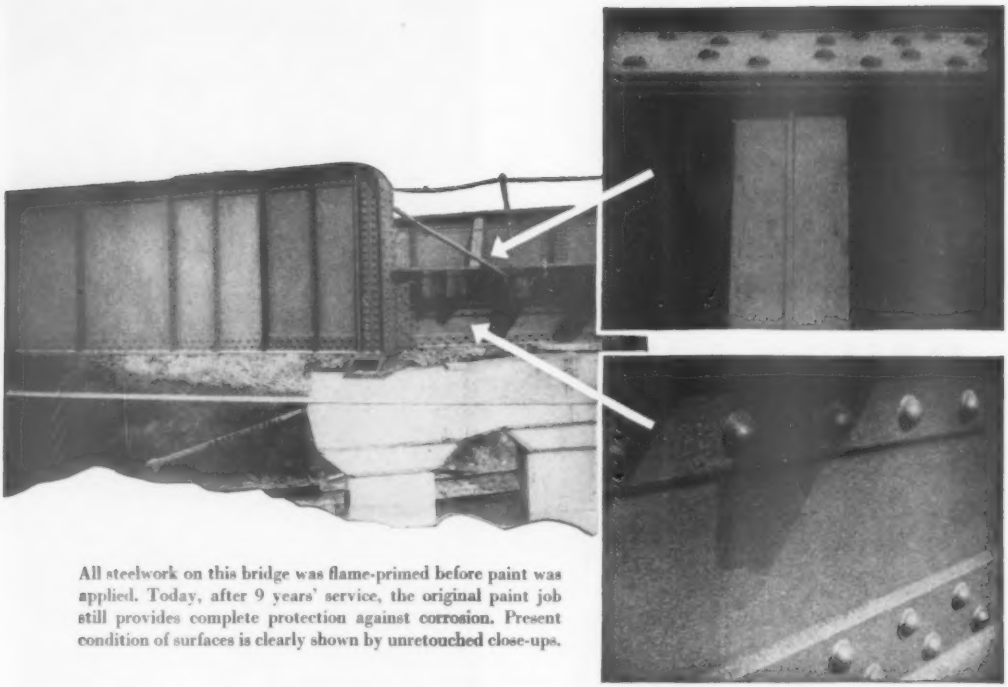
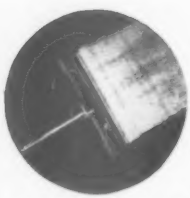


All steelwork on this bridge was flame-primed before paint was applied. Today, after 9 years' service, the original paint job still provides complete protection against corrosion. Present condition of surfaces is clearly shown by unretouched close-ups.

Your Steelwork . . .

How Will It Look in 1960?



Steelwork you coat with good paint today can still look like new ten years from now, *if you flame-prime all exposed surfaces first.* And what you'll save on maintenance, because of increased protection due to flame-priming, will more than pay for all the flame-priming apparatus and materials you need for the job.

Flame-priming is simple to do, requires little equipment, and costs little. A brush of oxy-acetylene flames pops off scale and drives out moisture. Paint applied to the warm, dry surface goes on quickly and smoothly, bonds tightly, and lasts longer.

Flame-priming is one of many time- and money-saving LINDE methods for making, cutting, joining, treating, and forming metals. So, whatever you do with metals, there is a good chance that LINDE know-how, show-how, and equipment can help you do it better, more quickly, or at lower cost.

To find out, without obligation, telephone or write our nearest office today. LINDE AIR PRODUCTS COMPANY, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in Other Principal Cities. In Canada: Dominion Oxygen Company, Limited, Toronto.

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Products and Processes for MAKING, CUTTING, JOINING, TREATING, AND FORMING METALS

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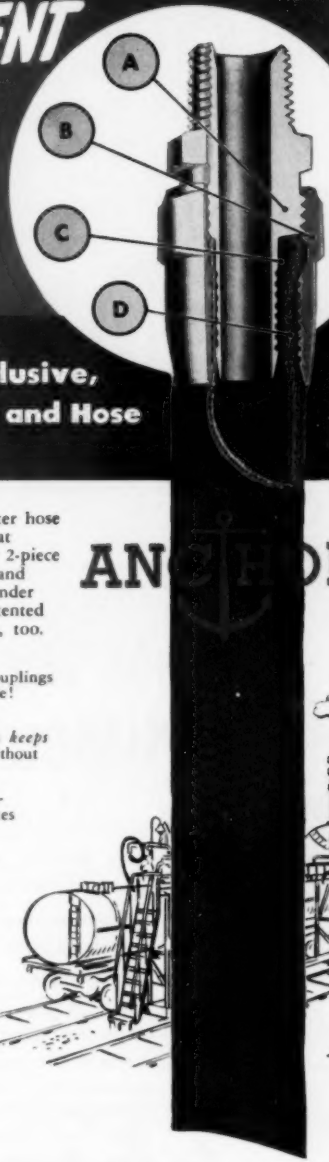
OIL-FIELD EQUIPMENT

stays "on the job" SAFELY, DEPENDABLY,

. . . when you use Anchor Exclusive, Patented Reusable Couplings and Hose



HOW IT WORKS

The thread on the body of the insert (A) and on the shell (B) is correctly designed to insure positive engagement and help prevent stripping. Anchor's exclusive patented grip provides additional packing of the hose in recess (C) and a uniform compression area (D).

All the things you want most in LPG, oil, air, and water hose assemblies — safety, dependability, easy assembly, neat appearance, lower inventories — are yours with Anchor 2-piece reusable couplings. Oil-field equipment manufacturers and users know that Anchor Couplings prove themselves under the most rugged field conditions. Anchor's exclusive patented design means money, time, and trouble saved for you, too. Look at these distinctive features:

EASY, FAST ASSEMBLY. The only tools needed to assemble couplings and hose are a wrench, an oil can, and a vise. It's that simple! Couplings can be used over and over again.

SAFER, MORE DEPENDABLE. Anchor's exclusive patented grip *keeps* hose assemblies performing *dependably* day-in, and day-out without attention — prevents leaks and dangerous blow-offs.

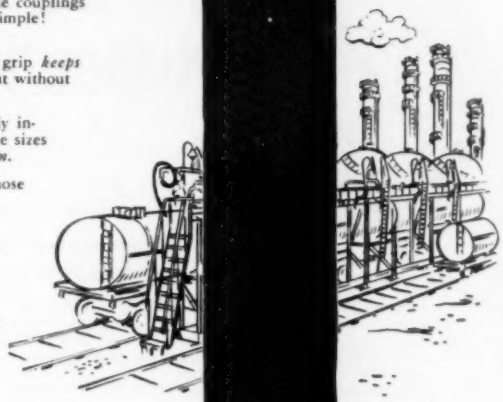
LOWER INVENTORIES. Costly prefabricated hose assembly inventories are eliminated. Just carry one coil of hose in the sizes you use. Cut it to lengths you need *when you need them.*

LESS DOWNTIME. Costly downtime in the field is cut. If hose assembly servicing is required, it can be performed immediately *without special tools.*

STREAMLINED DESIGN. Your jobs are neat and efficient, even in tight corners.

All the advantages in the most complete line of hydraulic hose assemblies and fittings available are yours with Anchor — advantages that mean your hose assemblies last longer, perform better, handle easier. So specify Anchor. Send coupon for further information.

ANCHOR



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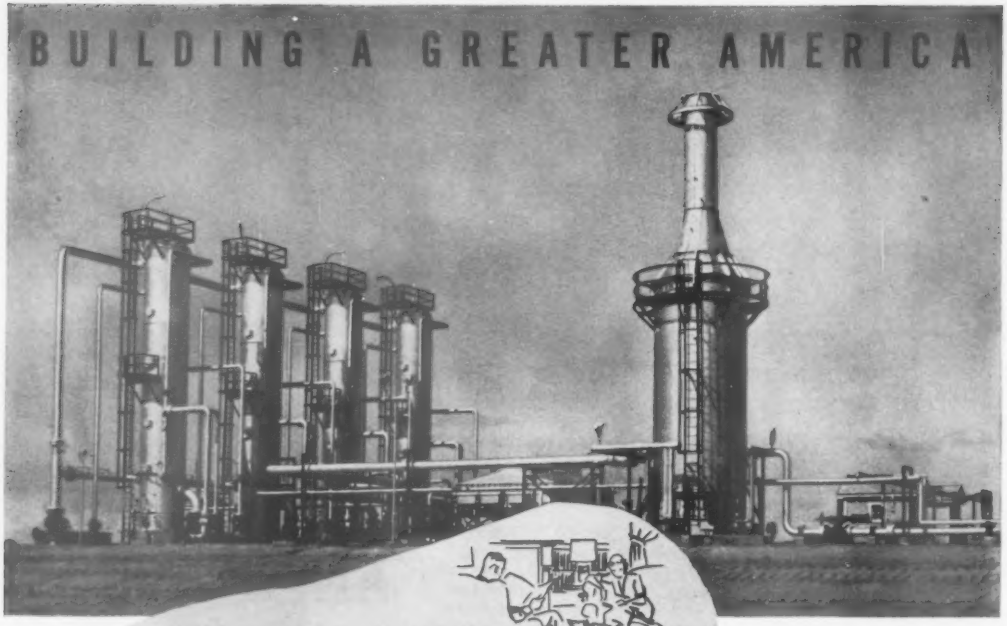
BUILDING A GREATER AMERICA



Built at Sun Ship, on the Delaware, these dehydrating towers now serve Western homes and industries.

Across the wide Missouri

Pioneers in prairie schooners blazed a courageous trail "across the wide Missouri . . ." and across the entire continent . . . in their search for new opportunity.

The industrial services of modern America have followed in that trail. Thriving farms, towns and cities mark sites where pioneers found only hardship . . . because American industry is truly "All-American."

Today, *all* America shares the benefits of *all* of America's progress . . . because great companies develop and distribute the advantages latent in our natural resources . . . and because great industries like Sun Ship can build and deliver, anywhere in the world, the gigantic equipment needed to convert petroleum and various chemicals into light, heat, power and the other productive forces which serve mankind's comfort and progress.

Sun

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PIPE LINE PROGRESS

2700 MILES OF LINE PIPE FOR Tennessee Gas Transmission System

Early in World War II, Tennessee Gas Transmission Company was authorized to construct its 24-inch natural gas pipe line from south Texas to West Virginia. Completed in 1944, this original line helped to supply fuel for the increasing demands of the central East.

This was but the beginning of a great natural gas transmission system that has continued to grow and expand. Today it serves additional markets in Ohio, New York and the New England states. The illustration shows recent 26-inch looping to increase main line capacity.

2700 miles of pipe in 16-inch, 20-inch, 24-inch and 26-inch diameters have been shipped by A. O. Smith as its part in supplying Tennessee Gas Transmission's requirements for the original as well as subsequent construction, including looping and extensions that have been completed and are in progress.

Ever since 1927, when A. O. Smith began volume production of welded steel line pipe and introduced internal expanded pipe to obtain greater yield strength, it has met the challenge of pipe line expansion. Today, A. O. Smith line pipe constitutes a large part of the petroleum and gas transmission systems that interlace this continent.

FIRSTS by A.O.Smith: Welded line pipe • Internally expanded pipe • Light-wall large-diameter pipe • World's largest producer of large-diameter welded steel pipe.

A. O. Smith Line Pipe is available in a complete range of sizes and wall thicknesses, from 8⅝-in. to 36-in. diameters.

The A.O.Smith Casing Mill is operating at capacity to supply vitally needed casing for the Oil and Gas Industry.

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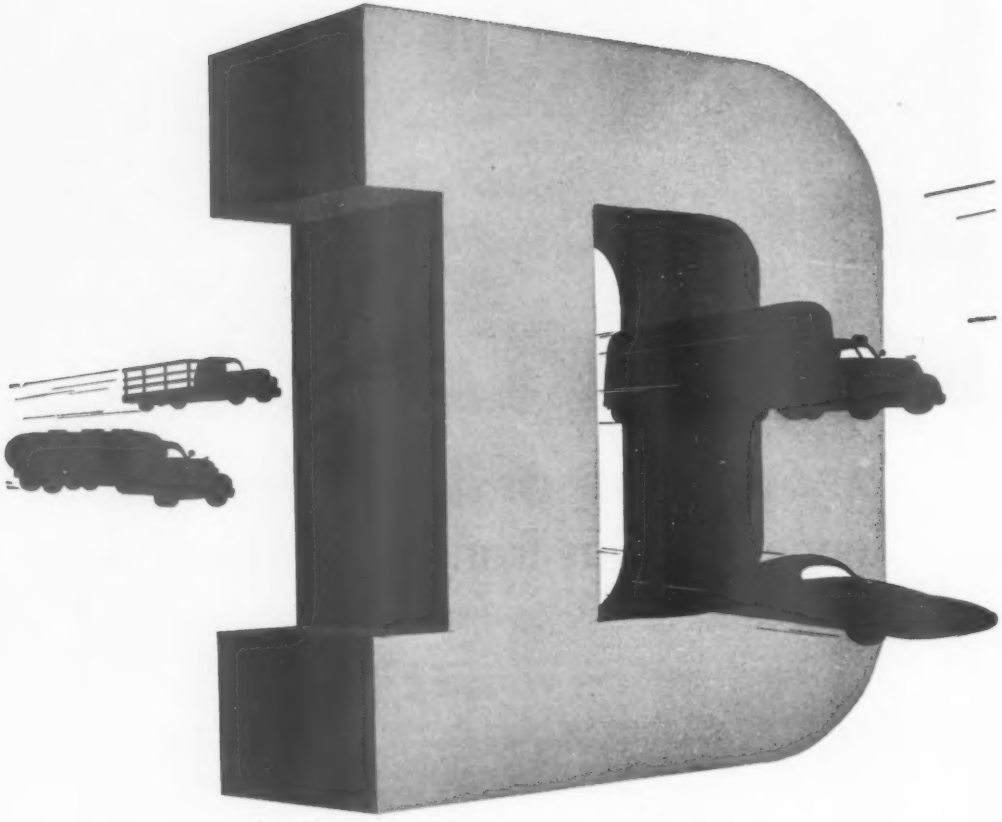
DEPENDABILITY THROUGH RESEARCH AND ENGINEERING



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The operating efficiency of synthetic fluid-type cracking catalysts is important. This operating efficiency can be assured by uniformity of physical characteristics and chemical purity. Davison's production of microspheroidal (M-S*) is tops in uniformity . . . providing all users with a highly efficient synthetic fluid-type cracking catalyst. Your requirements can also be supplied in ground (DA-1*) form. Write for further descriptive information. Experienced Davison Field Service Engineers backed up with complete laboratory testing facilities are part of Davison's service.

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The destructive action of drilling mud under high pressures can make short work of an ordinary valve. The very heart—the crucial seating area—can be washed out of a valve and into the mud pits in a matter of days. But not in the case of NORDSTROM *MUD LINE* VALVES! Nordstrom builds special Hypreseal valves for mud line service. There are no seats or discs in the line of flow to erode. Both the valve body and plug are protected by Merchroming, a Nordstrom process of weld-coating vital surfaces with an abrasion and corrosion resistant alloy. And the built-in internal lubrication system of Nordstrom valves makes it easy to operate always. ● There's a Nordstrom design for every drilling service—Write for Mud Line Bulletin No. V-201. Rockwell Manufacturing Company, 400 N. Lexington Ave., Pittsburgh 8, Pa.

Wherever you are in the oil fields, you're close to a supply house with Nordstrom valves and Nordstrom service.

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R-S valvEvents

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INSTALL R-S CHAINWHEEL VALVES

Few Chainwheel Turns. R-S Valves are completely closed from the fully open position by the movement of the valve vane through 77½° of arc. Operating ease is one of the chief advantages of R-S Valves.

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Consult your local R-S Valve Engineers, or write direct.

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Pipe protected by Hill, Hubbell lasts longer because we have absolute control over every step of the process. First the pipe is cleaned to bare metal with Roto-Grit Blast. Pipe is kept at uniform temperature while coatings and wrappings are precision applied, also at uniform temperatures. Every length is inspected with electronic holiday detectors before leaving the factory.

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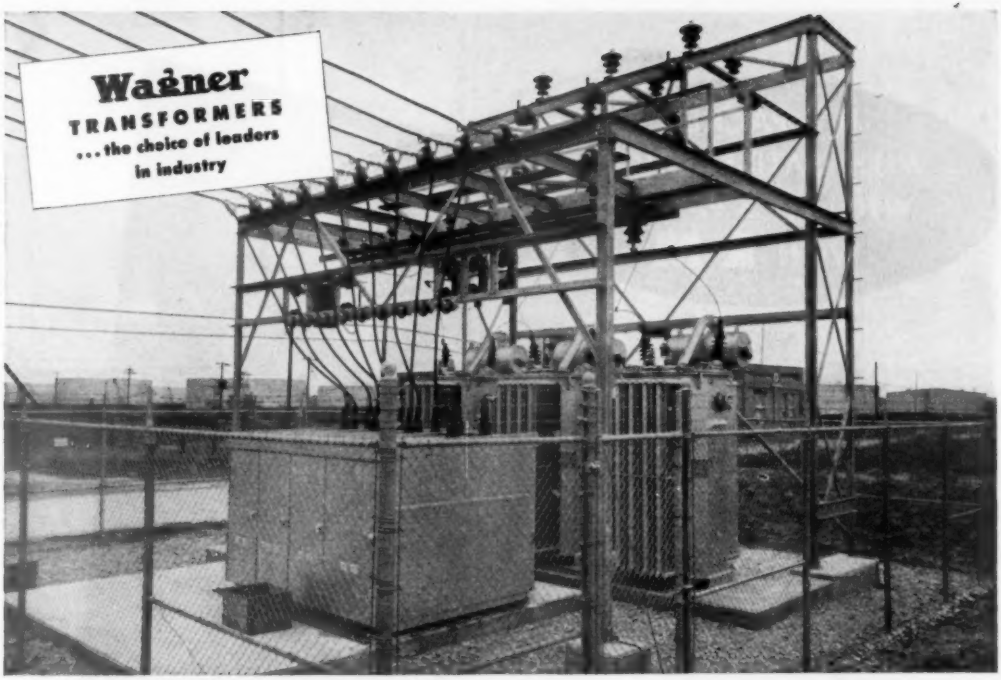


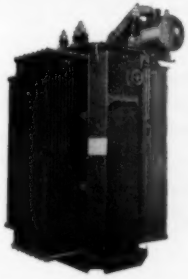
to keep the wheels of progress turning

The wheels of progress literally depend on petroleum products to keep them turning. Petroleum products, like those of The Texas Company, provide fuel for motive power, lubricants to help overcome friction, coolants to speed production — as a few examples. A steady flow of these vital products from the refinery depends, in turn, on a steady flow of electricity—the power for production.

Wagner Transformers, like this bank of 2000 kva power transformers at the Port Arthur plant of The Texas Company, steadily feed electric power at the right voltage for use in this plant.

Wherever electric power is used, in industry, commerce, city and farm — Wagner Transformers can be found, handling their never-ending job of supplying proper voltages for every purpose with complete dependability.

Wagner engineers are qualified to specify the correct transformer for *your* requirements. Consult the nearest of our 32 branch offices, or write us.



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AUTOMOTIVE BRAKE SYSTEMS — AIR AND HYDRAULIC

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WITH SATISFACTION
WHEN IT'S PACKED
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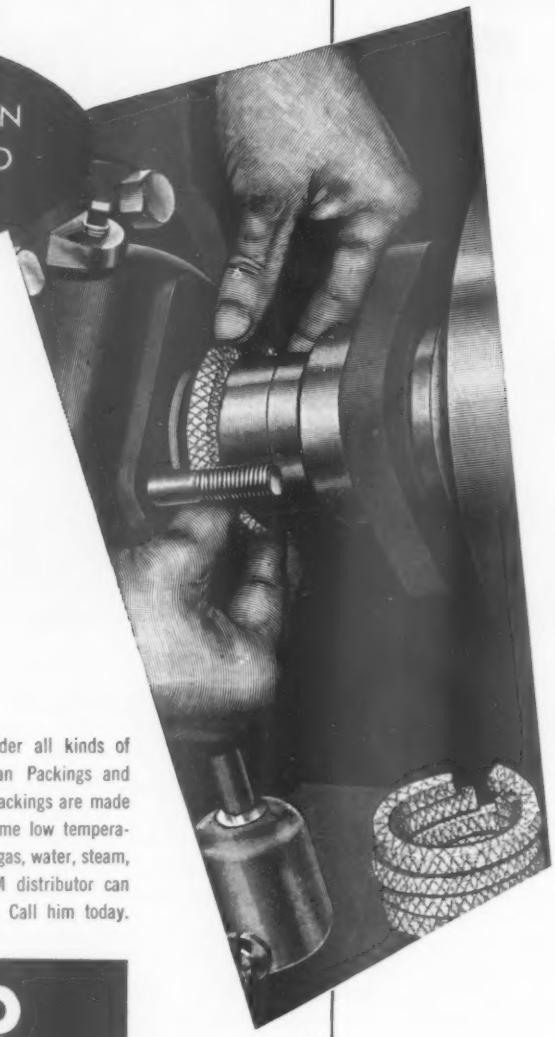

In high-pressure compressors like this, and under all kinds of difficult operating conditions, Raybestos-Manhattan Packings and Gaskets will give long, trouble-free service. R/M Packings are made for high pressures, high temperatures, and extreme low temperatures, as well as for service against caustics, acids, gas, water, steam, petroleum and other commercial fluids. Your R/M distributor can help you select the right packings for your plant. Call him today.

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THIS is the mark of McKee engineering. To oil men all over the world it means sound process and plant design, thorough, efficient engineering and construction. It is backed by an organization with the integrity and experience, the scope and resources to undertake your refinery project and fulfill the promise that *McKee Engineering means assured results.*

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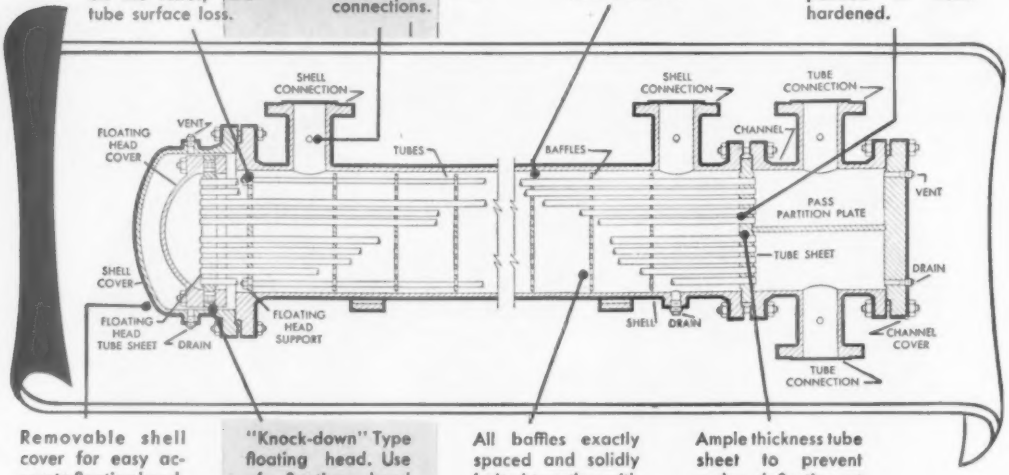
"Do-Nut" shape support plate offers maximum support to the floating head without undue strain on the tubes, and tube surface loss.

Connection for pressure gauge and thermometer provided on all flanged connections.

Baffles — cross flow segmental type machine cut and drilled. Close tolerances assure maximum heat transfer.

Tubes — expanded into tube sheets by means of electronic controlled roller expanders, tubes cannot be over expanded or work hardened.



Removable shell cover for easy access to floating head.

"Knock-down" Type floating head. Use of floating head minimizes thermal expansion strains.

All baffles exactly spaced and solidly bolted together with heavy tie rods and spacers.

Ample thickness tube sheet to prevent undue deflection at pass partition plate.

The features of design which make a heat exchanger *good* are the features which contribute most to efficient, long-lived, trouble-free performance *under your operating conditions*. Since operating conditions are seldom exactly duplicated, industrial heat exchangers are usually custom-built . . . and design characteristics are different for each application.

But while design characteristics differ, the fundamentals of good heat exchanger construction never change. If you are considering the purchase of heat exchanger equipment, we welcome the opportunity of showing you how SUPERIOR Heat Exchangers combine tested fundamentals with design features that fit your use . . . for performance you can BANK on.

Write for your copy of catalog 520

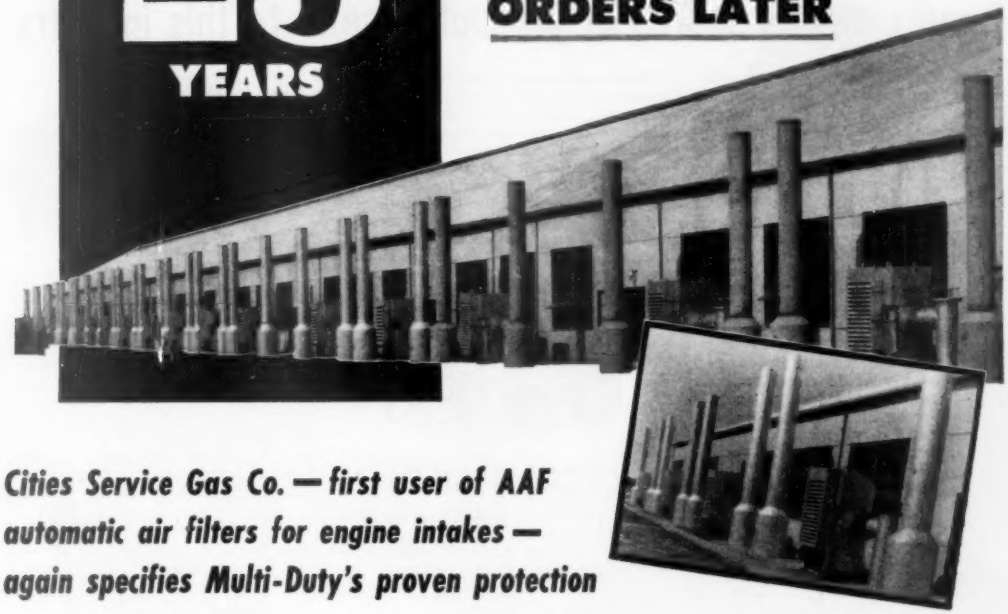
for performance you can **BANK** *on*

SUPERIOR HEAT EXCHANGERS

SUPERIOR COMBUSTION INDUSTRIES INC.
TIMES TOWER, TIMES SQUARE, NEW YORK 18, N.Y.

23 YEARS

AND MANY REPEAT ORDERS LATER



Cities Service Gas Co. — first user of AAF automatic air filters for engine intakes — again specifies Multi-Duty's proven protection

A lot of dust has blown across the Texas Panhandle since 1929—the year Cities Service Gas Co. installed their first Automatic Intake Air Filters.

This was the initial installation of automatic filters for air-intake cleaning. Only time would prove the wisdom of the customer's choice—the soundness of the manufacturer's design.

The answer has been supplied frequently over the past 23 years by this user's repeat purchases. Pictured above are two of their most recent installations at Hickox and Greenburg, Kansas. Here a total of 20 Multi-Duty Type CMS Filters are serving a like number of 1600 H. P. Cooper Bessemer gas booster engines.

The Multi-Duty has repeated this success story with scores of prominent users. The reason—continuous automatic cleaning of the filter curtain assures both constant efficiency and uniform air delivery regardless of dust load. And you get this dependable protection with a minimum of maintenance—just periodic inspection and regular sludge removal (without shutdown). For outdoor service filters are equipped with protective weather louvers and a plenum chamber for attachment to intake.

Write for Bulletin No. 130. See for yourself how the Multi-Duty makes efficient dust protection a low-cost, trouble-free, round-the-clock operation.

AAF

American Air Filter

COMPANY, INC.

444 Central Avenue, Louisville 8, Kentucky • American Air Filter of Canada, Ltd., Montreal, P. Q.

Here's how BENDIX *aids the flow of...*

Bendix makes scores of products useful to this industry

You who have a part in the petroleum industry shoulder heavy responsibilities. Whatever the future may bring in new sources of power and heat, the present internal economy and external safety of America depend on a constant flow of your products. The discovery of new fields . . . greater production from old wells . . . even more efficient refining methods . . . better utilization of existing supplies . . . and faster and more economical distribution—these are essential to the nation's welfare today as never before.

Bendix works in two important ways to help you fulfill these responsibilities. To forward technological advance in exploration, drilling, and refining, Bendix provides the services of 14 research centers and 4000 engineers skilled in the practical application of such sciences as electronics, hydraulics, chemistry, magnetics, pneumatics, meteorology, fuel combustion, instrumentation, metallurgy and nuclear energy to the solution of all manner of problems. And for these purposes, as well as for better utilization of present supplies and faster and more economical distribution, Bendix builds scores of products thoroughly tested for superior quality, reliability and efficiency under the extreme conditions so frequently encountered in petroleum operations. Here is a sampling from this lengthy list.

BENDIX VHF RADIO
assures reliable communication

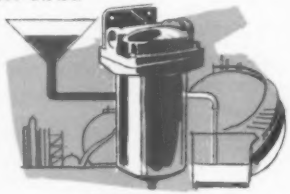
Communication—To speed such work as offshore drilling, exploration, and pipeline construction and maintenance, Bendix provides everything in radio from portable radio telephones to the planning and installation of complete radio relay systems. Exceptionally rugged and flexible, as proved in years of use by leading railroads in all parts of the country, Bendix equipment assures maximum range and reliability.

Instrumentation—From the experience gained as the leading producer of instruments and automatic controls for aviation, Bendix builds electronic devices and components of the special quality required for non-stop, automatic operation of refinery and pipeline processes and for dependable geophysical equipment. These products range from ruggedized electronic tubes for many purposes, thermistors, dynamotors, electrical connectors, and liquid level alarms,

BENDIX ELECTRONIC DEVICES
assure dependable instrumentation

to a complete line of temperature, humidity and wind indicating and recording instruments, water level recorders, telemetering systems, computing devices, and remote indicating and control equipment with a wide range of application.

Filtration—as the originator of micronic filtration and of the phenolic resin-impregnated cellulose elements which positively will not collapse and clog vital systems, Bendix is the logical source for filters for all fluids and gases. Present types number over 350, and additional types can be produced from the special Bendix filter elements to deliver positive filtration as fine as ½ micron with flow rate as high as 5000 G.P.M.



BENDIX FILTERS
assure the finest filtration

Fuel Metering—Bendix developments for providing the greatest power from petroleum products with minimum consumption have won this organization unquestioned preeminence in fuel metering. These developments cover all fields—from remarkably simple and efficient carburetors for small engines, trucks and passenger cars and precision diesel fuel injection equipment for railroad and marine engines, to highly intricate devices for reciprocal-engine planes, jets, turbo-jets and guided missiles.

BENDIX FUEL METERING
assures maximum fuel savings

BENDIX AUTOMOTIVE PRODUCTS
assure peak economy and service

Transportation—As one of the nation's largest users of trucks, the petroleum industry is also one of the biggest users of Bendix automotive products. To keep these huge fleets rolling at lowest cost, Bendix supplies not only carburetors but basic brakes, power brakes, brake blocks and lining, power steering, starter drives, fuel pumps and hydraulic controls—each the demonstrated leader in its field for reliability and long life.

Installation—Bendix products follow petroleum even into homes, office buildings and factories—to the greater efficiency of heating and air conditioning systems. For example, Bendix builds a portable temperature and humidity recorder widely used by heating contractors to test the efficiency of new and old installations.

SEE
Brilliant Bendix* TV
The Finest Picture Science has ever Produced.

PRINCIPAL DIVISIONS | BENDIX RADIO: auto, railroad, mobile, aviation radio; radar. LABORATORIES. ECLIPSE MACHINE: Stromberg® carburetors; electric fuel pump; starter drives; coaster brakes. MARSHALL RED BANK: dynamotors; inverters; special vacuum tubes. PACIFIC: telemetering; hydraulic and electrical aviation and small engine magnetos; diesel fuel injection; electrical connectors. BENDIX ECLIPSE OF

PETROLEUM PRODUCTS

BENDIX RECORDING INSTRUMENTS assure efficient heating installations

Another product of special interest to the industry is the Bendix low tension magneto which minimizes fire hazards at well heads by its unique "flame proof" construction.

As this abbreviated list indicates, if you deal with petroleum at any stage you ought to know more about Bendix. And this is true whatever your business, for Bendix products useful to this industry are only a fraction of the Bendix list. For valuable information on the many ways in which this versatile organization can help you evolve new products, improve your present line and cut manufacturing costs send for the Bendix book "Bendix and Your Business."

This informative 40-page book on Bendix services and products is available on request to interested executives, engineers and purchasing agents. Write on your letterhead to: Bendix Aviation Corporation, Fisher Building, Detroit 2, Michigan.

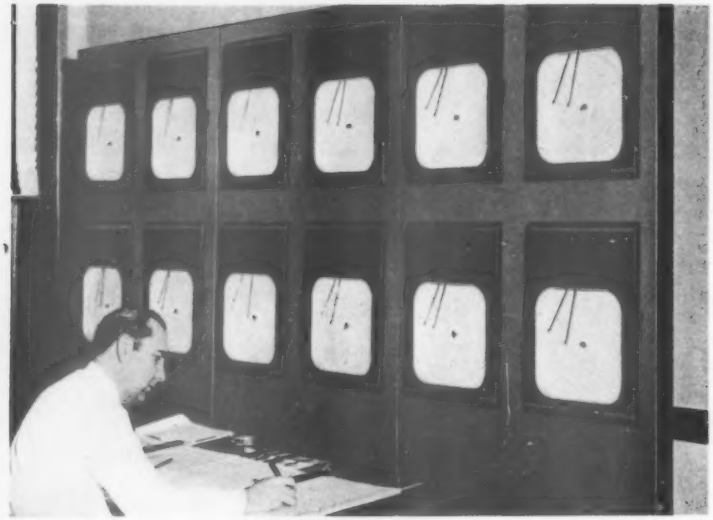
ENGINEERING STUDENTS—Send for the facts about the many fine careers open to you at Bendix plants and research centers. Write to Bendix Aviation Corporation, Research Laboratories, 1104 Fisher Building, Detroit 2, Michigan.

Bendix
AVIATION CORPORATION

THE NAME MILLIONS TRUST

BENDIX PRODUCTS: automotive brakes; power steering; carburetors; aviation brakes; landing gear; fuel metering. BENDIX AVIATION RESEARCH ECLIPSE: brake blocks; brake lining. ECLIPSE PIONEER: aviation instruments and accessories; foundry. FRIEZ: weather instruments. actuators; depth recorders. ZENITH* CARBURETOR: heavy duty and small engine carburetors. SKINNER PURIFIERS: filters. SCINTILLA MAGNETO: CANADA, LTD.—Windsor, Ontario. BENDIX INTERNATIONAL—72 Fifth Ave., New York 11, N. Y. Cable "Bendixint" New York.

*REG. U.S. PAT. OFF.



Metameter Telemeter Receivers in dispatching office, Midland Building, Kansas City, Mo., record suction and discharge pressures and static and differential pressures coming in by microwave from distances nearly 400 miles away. They give dispatcher a continuous visual picture of pressure conditions along Panhandle Eastern Pipe Line system.

MICROWAVE METAMETER TELEMETERING on the PANHANDLE EASTERN pipe line

Gives dispatcher the information he needs for better pressure regulation—enables him to foresee abnormal conditions and prevent interruptions—promotes greater operating efficiency

Bristol Metameter® Telemeters, using microwave transmission over some 400 miles of this company's pipe line system, bring readings of compressor suction and discharge pressures and static and differential pressures to the Kansas City dispatching office where they are recorded by 12 Metameter receivers within sight of the dispatcher.

Continuous information about suction and discharge pressure at Houstonia, Centralia, Pleasant Hill, Glenarm, and Tuscola, Ill., compressor stations and static and differential pressures at Tuscola enables the dispatcher to obtain better pressure regulation and to foresee abnormal situations and make corrections before they cause interruptions. Continuous observation of pressures along the pipe line system promotes economies and a feeling of security.

Metameter Telemeters are widely used with microwave radio communication systems. Provisions for future use or additional Metameter Telemeters are made on many microwave systems at the time of installation.

Other uses by pipe line companies include remote setting of regulators and flow controllers; remote readings of line pressure; sounding low and high pressure and flow limits alarms; totalizing flow through several lines.

For further information on the use of Bristol Metameters by pipe line and gas companies, from coast to coast, request Bulletin M1700, THE BRISTOL COMPANY, 120 Bristol Road, Waterbury 20, Conn.

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BRISTOL

The dependable Guidepost of Industry

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

These Plain, Hard Facts Prove It...

You save from start to finish with

CHEVROLET ADVANCE-DESIGN TRUCKS

Fact No. 1

THEY LIST FOR LESS

Chevrolet trucks *list for less* than any truck with comparable specifications that can handle an equal payload. Yet your money buys a combination of great truck features that you'll find only with Chevrolet. And that means value unmatched by any other truck in its field.

Fact No. 2

OPERATING COSTS SAVE YOU MONEY

Chevrolet's time-proved Thriftmaster and Loadmaster Valve-in-Head engines are famed for fuel, oil and upkeep economies. Extra-rugged frame, hypoid rear axle, Flexi-Mounted cab, and other features keep the truck rolling for many thousands of low-cost miles.

Fact No. 3

A MODEL THAT'S RIGHT FOR YOUR JOB

With Chevrolet's wide range of models, there's never the problem of "too little" or "too much" truck for the job. Each truck is factory-matched to its job. Standard body on standard chassis, or standard chassis for a special body, there's a Chevrolet truck to cut your costs.

Fact No. 4

YOUR INVESTMENT EARNS A HIGHER RETURN

Big demand for Chevrolet trucks means a traditionally higher price when you trade your Chevrolet for a new one. You save money all the way with a Chevrolet—from the day you buy it until the day you trade it. See your Chevrolet dealer now—and save!

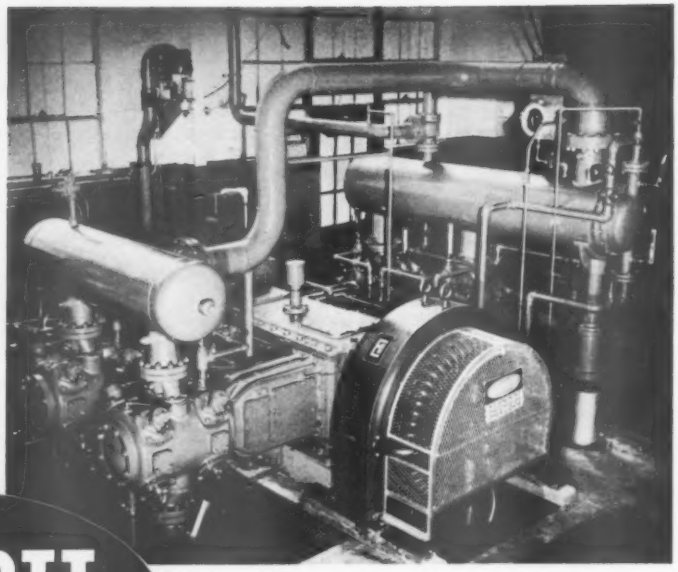
CHEVROLET ADVANCE-DESIGN TRUCK FEATURES

TWO GREAT VALVE-IN-HEAD ENGINES—Loadmaster or the Thriftmaster—to give you greater power per gallon, lower cost per load • POWER-JET CARBURETOR—for smooth, quick acceleration response • DIAPHRAGM SPRING CLUTCH—for easy-action engagement • SYNCHRO-MESH TRANSMISSION—for fast, smooth shifting • HYPOID REAR AXLE—for dependability and long life • TORQUE-ACTION BRAKES—on light-duty models • PROVED DEPENDABLE DOUBLE-ARTICULATED BRAKES—on medium-duty models • TWIN-ACTION REAR BRAKES—on heavy-duty models • DUAL-SHOE PARKING BRAKE—for greater holding ability on heavy-duty models • CAB SEAT—with double-deck springs for complete riding comfort • VENTI-PANES—for improved cab ventilation • WIDE-BASE WHEELS—for increased tire mileage • BALL-TYPE STEERING—for easier handling • UNIT-DESIGNED BODIES—for greater load protection • ADVANCE-DESIGN STYLING—for increased comfort and modern appearance.

CHEVROLET DIVISION OF GENERAL MOTORS, DETROIT 2, MICHIGAN

CHEVROLET first in demand in value in sales

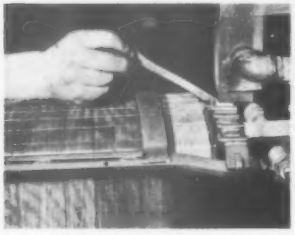
THE IDEAL DRIVE FOR GAS COMPRESSORS



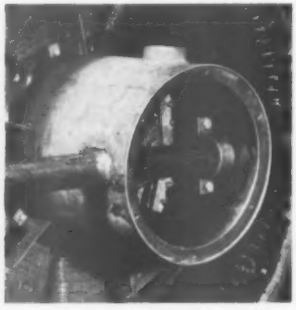
ELLIOTT *Synchronous* MOTORS

This Elliott synchronous motor drives a Clark CMA-4 compressor. It is featured by the rigidity and strength of its Elliott "Fabri-Steel" construction in frame and stator core plus a number of unique design and construction advantages.

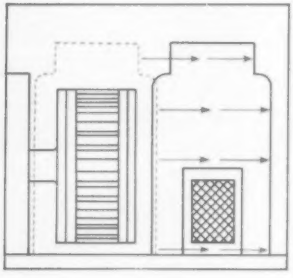
ONE OF MANY REASONS FOR ELLIOTT RELIABILITY Starting winding bars are SILVER-BRAZED to heavy end ring segments, insuring a permanent, high strength joint, with highest electrical and thermal conductivity. Photo illustrates how an assembly jig is used during silver-brazing to guarantee accurate alignment of parts.



Long-wearing steel collector rings are completely enclosed and pressure ventilated with uncontaminated air. A transparent removable window permits inspection or quick replacement of brushes.



The overhung motor rotor reduces space requirements, eliminates need of an outboard bearing, and increases efficiency. Inspection of the entire stator core and field poles is simple, since the frame can be shifted along its foundation to clear the rotor.



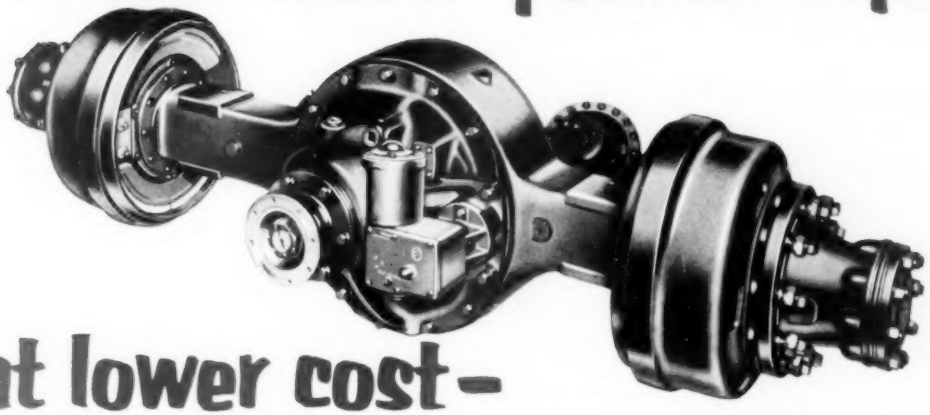
ELLIOTT Company R2-1

DEPT. O&G

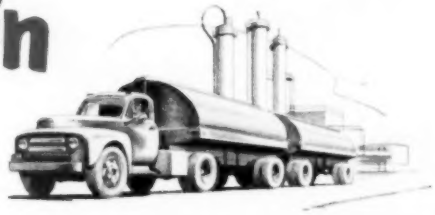
Ridgway Division
RIDGWAY, PA.

Plants at: JEANNETTE, PA. • RIDGWAY, PA.
AMPERE, N. J. • SPRINGFIELD, O. • NEWARK, N. J.
DISTRICT OFFICES IN PRINCIPAL CITIES

EATON 2-Speed equipped Trucks make quicker trips



at lower cost – last longer, are worth more on the trade-in



With Eaton 2-Speed Axles drivers select the gear ratio best suited to road, load, and traffic conditions—the ratio for maximum economy, safety, and maneuverability. Quicker trips with full loads mean more payload miles at lower cost per mile. Engines run in the most efficient and economical speed range, reducing stress and wear on engines and all power transmitting parts. Trucks stay on the job, out of the repair shop. Thousands of miles are added to vehicle life; trucks are worth more when they are traded in.

Let your truck dealer explain how Eaton 2-Speeds will enable your trucks to haul more, faster, longer, at lower cost.

EATON
2-Speed Truck
AXLES

Axle Division
EATON MANUFACTURING COMPANY
CLEVELAND, OHIO

Today, America's roads are crowded with twice the traffic they were designed to carry. Help end the national traffic jam by speaking up for more and better roads.

Choice of 7 Case Designs

WHEN YOU SPECIFY

ASHCROFT DURAGAUGES

SPECIFIC NEEDS are your best guide in selecting a pressure gauge casing. Ashcroft Duragauge Casings, made in three distinctly different types of material and seven different designs, meet practically every installation and service requirement:

ALUMALIFE®—a special aluminum alloy that is light, strong and has excellent overall resistance to corrosion and vibration.

CAST IRON—tough and durable. Used in corrosive conditions where aluminum would not be suitable.

PHENOL—light, strong, rigid plastic that is acid-proof and corrosion proof.

Every Duragauge case is dust and moisture-proof, and the entire gauge system can be easily removed from the case *as a unit*.

To insure peak performance and maximum service life in specific installations, you can choose an Ashcroft Duragauge with the Bourden Tube made of any one of eight different types of materials. All provide unusually long tip travel, consequently greater accuracy of indication is assured. The patented Nylon Movement outwears all others. And the micrometer adjustment pointer is easy to get at and reset precisely while on the shaft.

Remember, only Ashcroft Duragauges give you all these advantages. So—ask the nearby Ashcroft Distributor to help you choose Duragauges that fit your needs exactly.

ASHCROFT DURAGAUGE CASE MATERIALS, MOUNTING AND DIAL SIZES

CASE	BACK FLANGE	MOUNTING		CONNECTION		DIAL SIZE
		WALL	FLUSH	LOWER	BACK	
Black Alumalife® with flat, threaded Alumalife ring	Yes	Yes	Yes	Yes	Yes	4½", 6"
Black Cast Iron with flat, threaded ring of Alumalife on 4½" and 6" and Bronze on 8½", 10" and 12"	Yes	Yes	Yes	Yes	Yes	4½", 6" 8½", 10", 12"
Black Phenol Turret with snap ring	No	Yes	Yes	Yes	Yes	4½", 6", 8½"
Black Phenol with threaded phenol ring. Safety blowout disc is standard	Yes	Yes	No	Yes	Yes	4½", 6", 8½"
Black Alumalife with special ring held tightly at top by a hinge pin and at bottom by a clamp screw	No	No	Yes	No	Yes	4½", 6", 8½"
Black Cast Iron with special ring held tightly at top by a hinge pin and at bottom by a clamp screw	No	No	Yes	No	Yes	4½", 6", 8½" 10", 12"
Black Alumalife with black clamp slip ring	Yes	Yes	No	Yes	No	4½", 6"

ASHCROFT GAUGES

A product of **MANNING, MAXWELL & MOORE, INC.** STRATFORD, CONNECTICUT

MAKERS OF 'ASHCROFT' GAUGES, 'HANCOCK' VALVES, 'CONSOLIDATED' SAFETY AND RELIEF VALVES, 'AMERICAN' INDUSTRIAL INSTRUMENTS, BUILDERS OF "SHAW-BOX" CRANES, BUDGIT AND 'LOAD LIFTER' HOISTS AND OTHER LIFTING SPECIALTIES.

HERE'S WHY ENGINEERS SELECT YOUNG HEAT EXCHANGERS

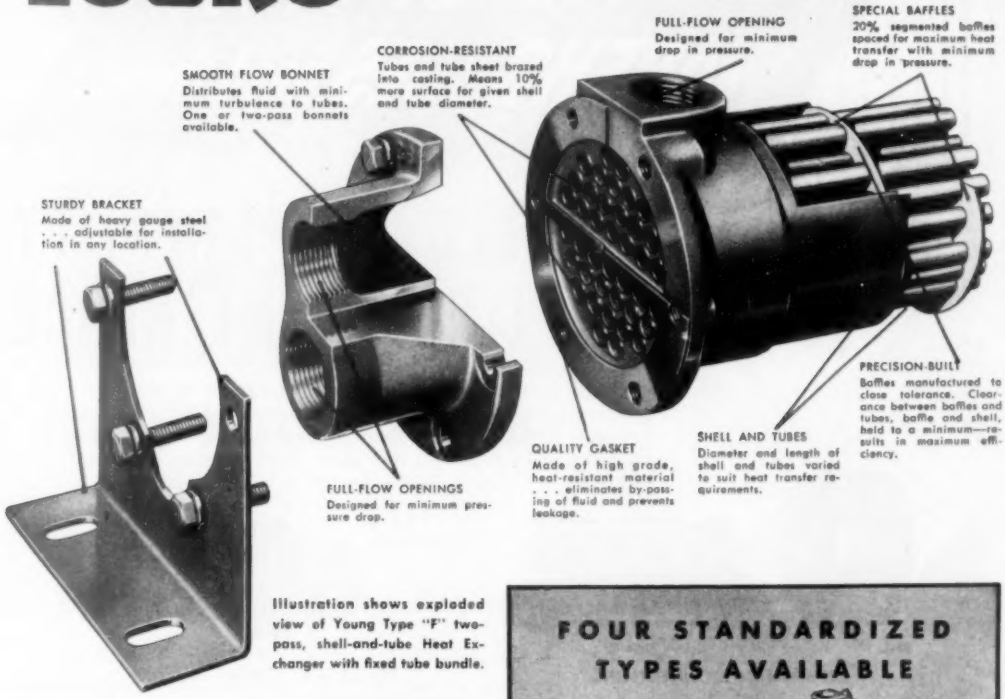

SMOOTH FLOW BONNET
Distributes fluid with minimum turbulence to tubes. One or two-pass bonnets available.
CORROSION-RESISTANT
Tubes and tube sheet brazed into casting. Means 10% more surface for given shell and tube diameter.
FULL-FLOW OPENING
Designed for minimum drop in pressure.
SPECIAL BAFFLES
20% segmented baffles spaced for maximum heat transfer with minimum drop in pressure.
STURDY BRACKET
Made of heavy gauge steel . . . adjustable for installation in any location.
PRECISION-BUILT
Baffles manufactured to close tolerance. Clearance between baffles and tubes, baffle and shell, held to a minimum—results in maximum efficiency.
QUALITY GASKET
Made of high grade, heat-resistant material . . . eliminates by-passing of fluid and prevents leakage.
SHELL AND TUBES
Diameter and length of shell and tubes varied to suit heat transfer requirements.
FULL-FLOW OPENINGS
Designed for minimum pressure drop.

Illustration shows exploded view of Young Type "F" two-pass, shell-and-tube Heat Exchanger with fixed tube bundle.

COMPACT UNITS . . . PRECISION MANUFACTURED . . . STANDARD DESIGN . . . QUICK DELIVERY

Young standardized Heat Exchangers, recognized for their compactness in design, provide maximum heat transfer per unit volume of available space with minimum weight. They are used for any kind of fluid to fluid cooling. Single or multi-pass units—fixed tube bundle Type "F" and removable tube bundle Type "R"—are available in ferrous and non-ferrous metals and complete range of sizes. Type "F" units are shipped from stock, and Type "R" units are available for quick delivery. Write for catalogs 1049 and 1149.

YOUNG

Heat Transfer Products for Automotive and Industrial Applications.

Heating, Cooling, Air Conditioning Products for Home and Industry.

YOUNG RADIATOR COMPANY

Dept. 202-L • RACINE, WISCONSIN

Factories at Racine, Wisconsin and Mattoon, Illinois

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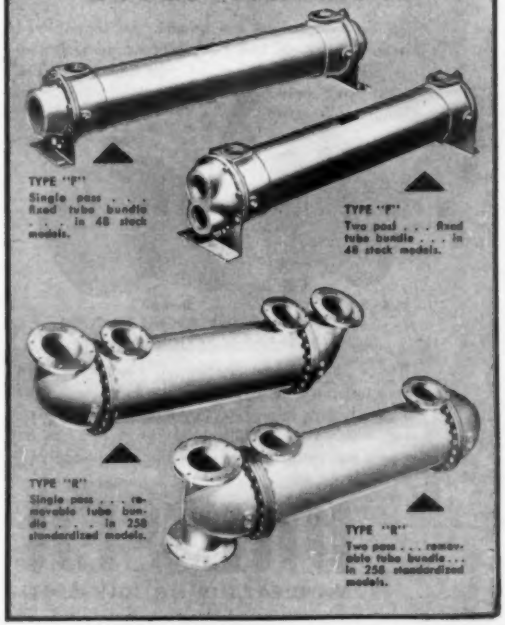
LOS ANGELES: Flournoy & Everett, Inc., 5043 Santa Fe Ave.
MUSKEGON: Harold J. Young, 206 Montgomery Bldg.
Other Representatives in Principal Cities

FOUR STANDARDIZED TYPES AVAILABLE

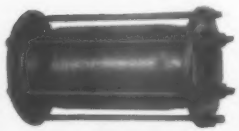

TYPE "F"
Single pass . . . fixed tube bundle . . . in 48 stock models.
TYPE "F"
Two pass . . . fixed tube bundle . . . in 48 stock models.
TYPE "R"
Single pass . . . removable tube bundle . . . in 258 standardized models.
TYPE "R"
Two pass . . . removable tube bundle . . . in 258 standardized models.

EMERGENCY STOCK WAREHOUSES need these...

TO SPEED AND SIMPLIFY PIPE LINE MAINTENANCE

It always pays to stock Dresser Repair Equipment up and down the line to save valuable time in making repairs. Furnished for pressures as high as 1000 lbs. or more, these products make short work of dozens of maintenance problems. Buy them direct or from our Houston or South San Francisco Warehouses. Write today for catalog.

Style 38



Style 40

DEPENDABLE CONNECTIONS

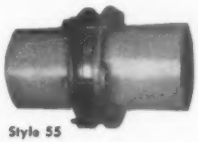
For fast connections and repairs, use time-proved Dresser Couplings and Long Sleeves. Ideal for replacing damaged sections of pipe and for tie-ins. Quick and easy assembly—permanently tight. Complete size range.

Style 93

Style 96

FOR BREAKS, SPLITS, HOLES

Dresser Split Repair Sleeves are a quick, efficient means of repairing breaks, splits, holes and other failures in pipe lines. Easy to install. No loose parts—no welding. Self-sealing end-gasket pressure increases as line pressure increases. Sizes 6" through 24".



Style 55

TO REPAIR POROUS WELDS

Dresser Porous Weld Clamp stops leaks fast, without shutting down the line. Simply put it around the weld and draw up the bolts. You get a permanent repair in a matter of minutes. Sizes 2" through 31".

Style 110

Style 111

REINFORCING SLEEVES

Now available from Dresser in the best grade flange-quality steel plate. Uniformly perfect shaping assures easy installation. Vented against pressure build-up. Order Dresser Welding Sleeves for welded lines, Weld-over Sleeve for coupled lines. Can be furnished in special sizes and shapes when production quantities are involved.

DRESSER
MANUFACTURING DIVISION

59 Fisher Ave., Bradford, Pa. (One of the Dresser Industries). Warehouses: 1121 Rothwell St., Houston, Texas, 101 S. Bayshore Highway, South San Francisco, California.

the Modern Miracles of MAGNAFLUX...

how they save time, money, lives!

MAGNAFLUX
How magnetic force is put to work to detect defects in magnetic materials—even when below the surface.

MAGNAGLO
How a "line of light" is created at any defect to make location easy.

ZYGLO
How a fluorescent penetrant works with black light to spot defects in non-magnetic metals.

STATIFLUX
How electrified particles locate defects in ceramics, glass, plastics and other non-conductors.

PARTEK
How defects in porous materials—concrete, unfired clay, sintered ware, etc.—are detected by filtered particle inspection.

SONIZON
How sound you can't hear measures thicknesses you can't see.

STRESSCOAT
How a sprayed-on, brittle coating simplifies stress analysis.

THIS BOOK TELLS How and Why

. . . and it's YOURS for the Asking!

Here's an extremely interesting, enlightening, and easy-to-understand book! It tells the dramatic story of Magnaflux inspection methods—how, even now, these miracles of modern science are working night and day to make good products better. How they save money and increase production,—improve maintenance,—and safeguard life and property!

In simple, understandable words, plus more than a score of graphic illustrations, it explains how Magnaflux methods *detect defects* in metals and other materials—how Magnaflux makes it possiple to *see below the surface;* how it makes *invisible* imperfections *visible!* . . . This book tells and shows you what you need to know about all the related inspection methods and equipment *pioneered* and *perfected* by the Magnaflux Corporation.

DO THESE "HOWS" SOUND INTERESTING? . . .

Then mail the coupon today—NOW—for your FREE copy of *"Seeing Isn't Always Believing . . . It depends on what is seen!"* Discover how the methods and equipment developed by Magnaflux for non-destructive inspection can work for YOU.

MAGNAFLUX

DETECTS DEFECTS

MAGNAFLUX CORPORATION

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New York 18 • Dallas 9 • Detroit 11 • Cleveland 15 • Los Angeles 58

MAGNAFLUX CORPORATION
5928 Northwest Hwy., Chicago 31, Illinois

May I have a personal copy of the booklet "Seeing Isn't Always Believing"?

Name_____

Company Name_____

Address_____

City_____ Zone____ State_____

"Not houses finely roofed

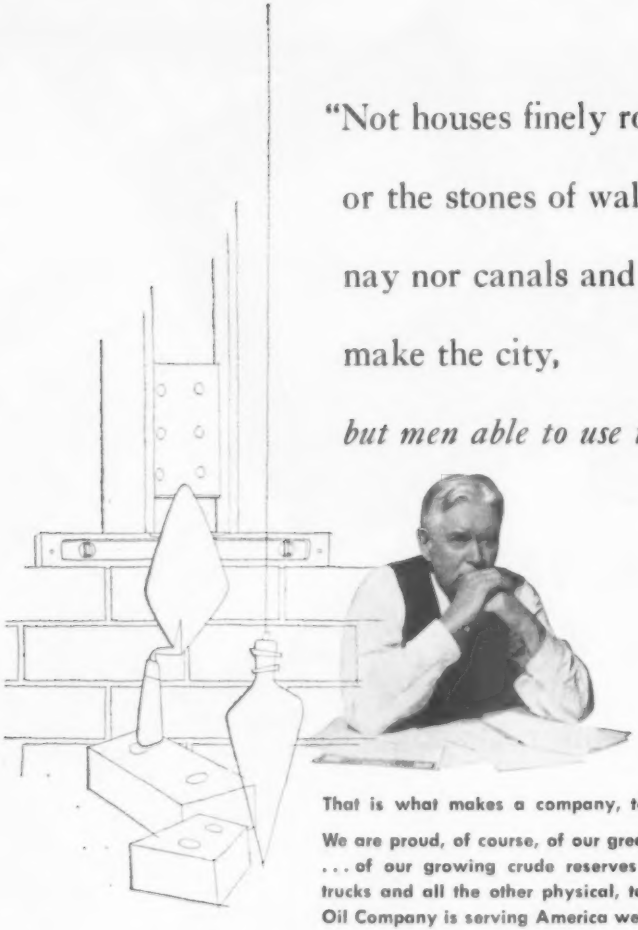
or the stones of walls well-builded,

nay nor canals and dockyards

make the city,

but men able to use their opportunity."

—Alcaeus, 611-580 B. C.



That is what makes a company, too—particularly one like ours!

We are proud, of course, of our greatly expanded refining facilities . . . of our growing crude reserves . . . of our pipe-lines, tankers, trucks and all the other physical, tangible evidence that The Pure Oil Company is serving America well.

But we are *proudest* of our *people.*

Wherever they work—whatever they do—wherever they are—in all the different jobs our company provides—they are showing that they are *able to use* the great opportunity given them by America's need for petroleum products, and America's way of meeting the need.

At last count, the Pure Oil family included 10,800 employees and 15,000 associated dealers.

If length of service is any indication, they must think the same about Pure Oil as Pure Oil thinks of them.

Here's the year-by-year standing of those employees who have been with us for more than ten years:

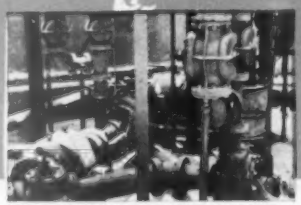
employees with over 10 years service

	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49
Production	469	299	184	158	83	9	3	..
Refining	74	237	220	153	31	2	..	..
Transportation	88	75	60	33	17	5	4	..
Marketing	132	141	108	83	21	8	9	1
General Office	114	96	115	76	53	10	3	2
Total	877	848	687	503	205	34	19	3

BE SURE PURE WITH PURE

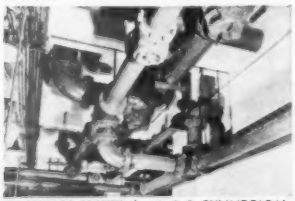
THE PURE OIL COMPANY

FULL PIPE SIZE AREA



IN THE CHEMICAL and INDUSTRIAL PROCESSING FIELD a.c.f. Round Port CYLINDRICAL Plug Valves handle abrasive ladings, such as cement slurry, coal wash water, etc., without erosion—and have long life.

IN PETROLEUM and GAS INSTALLATIONS a.c.f. Valves give full-area flow with fast, positive shut-off.



IN SEWAGE PLANTS the a.c.f. CYLINDRICAL Plug shears obstructions on raw sewage lines . . . provides uninterrupted flow.

a.c.f.'s Full Round Port, CYLINDRICAL Plug Valve has a straight level-through flow passage the same size and shape as the pipe itself! This means fast unobstructed flow of heavy or viscous ladings, solids in suspension, all liquids and gases.

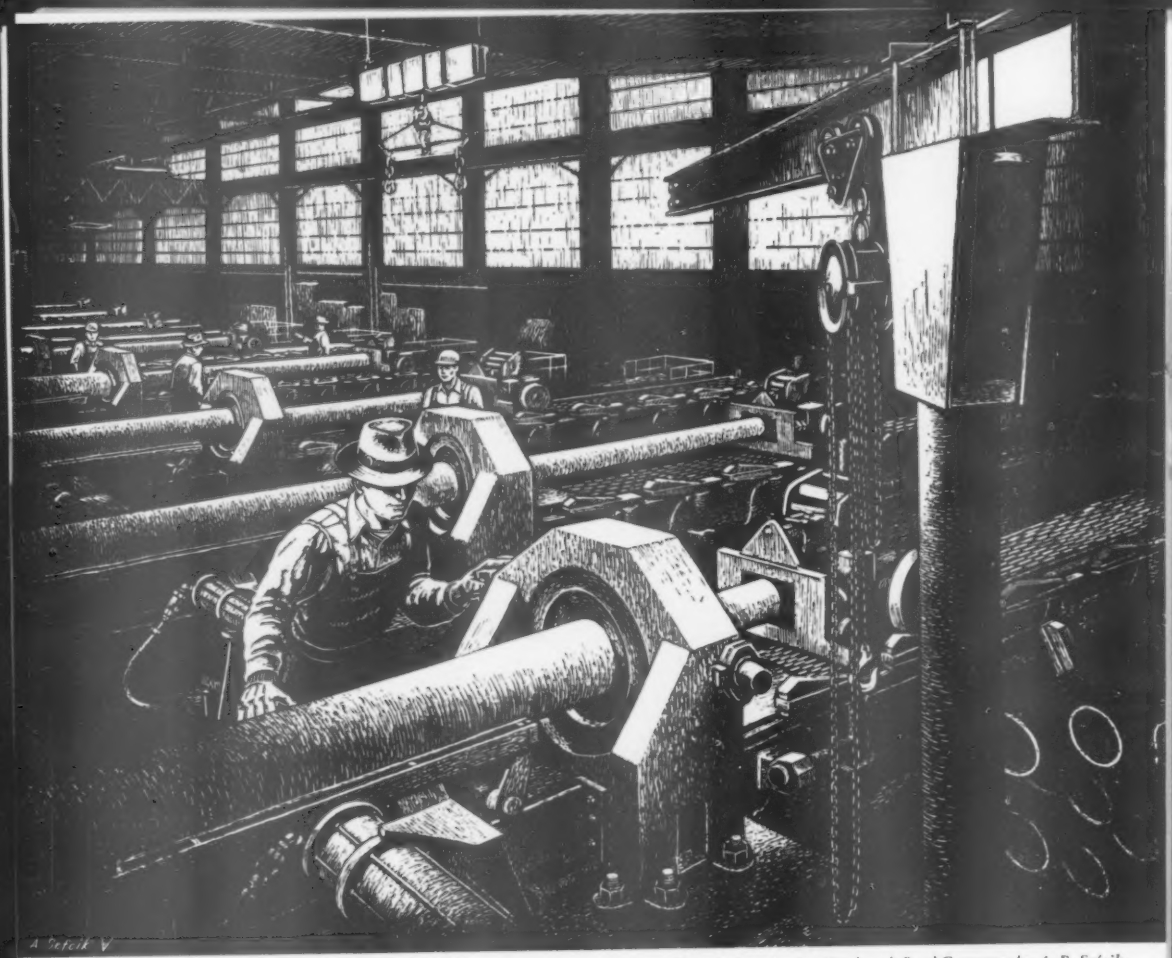
And—there is full straight-through pipe area in a.c.f.'s Rectangular Port, CYLINDRICAL Plug Valve, too.

Investigate—you need "full pipe size area" valves for economical processing.

a.c.f. CYLINDRICAL FULL PIPE AREA PLUG VALVES

Write for Catalog 4-OG, American Car and Foundry Co., Valve Division, 1502 E. Ferry Ave., Detroit 11, Michigan

Representatives in 50 Principal Cities



Cold Drawn Mechanical Tubing

Scratchboard Drawing for Pittsburgh Steel Company by A. B. Sefcik

Progress in Steel . . . *Means More Special Tubing*

Cold drawn seamless tubing has long been a specialty at Pittsburgh Steel Company. Upon completion of its Program of Progress, which is increasing finished product capacity by 82% and ingot capacity by 50%, this high-quality product will become available in even greater quantities for many vital defense and civilian needs.

For example, the importance of Pittsburgh Mechanical Tubing to defense is demonstrated by the fact that it serves in such diversified ways as bushings for tank tracks, cylinders for aircraft hydraulic equipment — even as rocket launching tubes. Civilian uses include automobile drive shafts, pump plungers, and parts for farm equipment and machine tools, to name but a few.

Many manufacturers find that Pittsburgh Seamless Cold Drawn Mechanical Tubing has the uniform physical qualities, size accuracy, and fine surface finish that makes it easy to machine—saves production time, cuts costs, and improves product performance. Also important to defense and civilian needs are other Pittsburgh Steel tube specialties for power plants, boilers, condensers, and refinery stills.

The expanded output of these important products will be made possible by the extensive $60-million Program of Progress which is designed to round out the company's line of products better to serve its customers. They in turn will be able to accelerate their production of vital items necessary to speed our national defense program—at the same time maintain a high level of civilian economy.

Program of Progress

Acquisition of Thomas Steel Company	100% Complete
Installation of new 66-inch High Lift Blooming-Slabbing Mill	100% Complete
Increase of Blast Furnace Capacity by 12% Per Year	60% Complete
Increase of Open-Hearth Capacity by 50% Per Year	50% Complete
Installation of Continuous 66-inch Hot Rolled Sheet-Strip Mill	70% Complete
Installation of 66-inch Cold Rolled Sheet-Strip Mill	50% Complete

Pittsburgh Steel Company

Pittsburgh, Pennsylvania

VITAL JOB FOR GAUGES

...only the best can measure up to it

That panel board is the nerve center of the rig . . . and those ten pressure gauges actually guide every move of the operator. This is no place to take chances on instruments of questionable quality; so the manufacturer of the rig—Emsco Derrick & Equipment Co. —has chosen the gauges that have proved worthy of this kind of trust . . . Marsh Gauges.

The choice of Marsh instruments by manufacturers of highest quality equipment in which pressure indication plays a vital part, is a familiar story. And the reason for this preference is equally familiar to everyone who has rubbed elbows with those dependable Marsh Gauges that are doing their job so supremely well wherever oil flows.

Marsh Gauges have been accorded top preference in the petroleum industry because they have set new standards all their own. Ask your supply house for facts or write for bulletins.

MARSH INSTRUMENT CO. *Sales affiliate of Jas. P. Marsh Corporation* **Dept. L, Skokie, Ill.**
HOUSTON BRANCH PLANT: 1121 Rothwell St., Sect. 15, Houston, Texas

MARSH GAUGES

FOR Safety's SAKE...

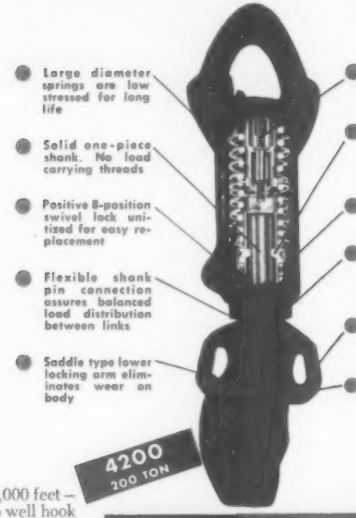
USE BJ SUPER-TRIPLEX HOOKS

SAFETY...STRENGTH...LONG SERVICE...ADAPTABILITY...

YOU'LL discover the solution to the toughest hook problem is a Byron Jackson Super-Triplex Hook. Over 24 years of experience manufacturing quality oil tools have gone into the design of the Super-Triplex line. This "know how" pays off in long, efficient service, built-in strength and safety, and greater adaptability of design of each BJ hook. Whatever your drilling requirements, you'll find Super-Triplex Hooks are built to withstand the heavy loads of modern drilling operations. There's a size for every type of drilling... BJ engineered to fit your rig.

Here's how BJ makes better hooks:

- Only select, magnafluxed, heat-treated steels used
- 4:1 Safety Factor — Crews work better because they're safer
- Hooks rotate easily under all loads
- Close metallurgical supervision throughout manufacture
- "Floating Action" springs for easy handling of all loads
- All BJ hooks made to API standards



- Large diameter springs are low stressed for long life
- Solid one-piece shank. No load carrying threads
- Positive 8-position swivel lock unitized for easy replacement
- Flexible shank pin connection assures balanced load distribution between links
- Saddle type lower locking arm eliminates wear on body
- Sub-shank threads carry up thrust load of springs only
- Swivel ring accurately machined to seat shank when hook fully loaded
- Ball bearings 100% rated for each size hook
- Rugged housing supports load and protects working parts from dirt and grit
- Upper locking arms open downward for easy entrance of links
- Heavy body overhang takes swivel bail pounding

4200 200 TON

To 10,000 feet — Deep well hook designed for average 10,000 foot wells or maximum work load of 200 tons. Weight of hook 4,565 lbs.

4300 300 TON

Over 10,000 feet — Deep well hook designed to handle the heaviest strings of drill pipe and casing used in modern drilling. Weight of hook 5,800 lbs.

4125 125 TON

To 7,000 feet — Medium well hook designed for wells to 7,000 feet or maximum load of 125 tons. Weight of hook 3,045 lbs.

460 60 TON

To 5,000 feet — Shallow well hook is also available.

BJ MEANS ENGINEERED OIL TOOLS

Byron Jackson Co.

MAIN OFFICE & PLANT: LOS ANGELES 54, CALIF.

OIL FIELD & INDUSTRIAL SPECIALTIES

For more detailed data, write for Super-Triplex Bulletin, or call your local BJ Oil Tool Representative.

A new "Baby" has arrived!

LORAIN TL-10 TRUCK CRANE

for mounting on your new or used truck

now with the LORAIN TL-10

YOUR THEW-LORAIN DISTRIBUTOR CAN OFFER A CRANE FOR *EVERY* NEED

Even before the new TL-10 Truck Crane was "born", your Thew-Lorain Distributor offered the world's most complete selection of cranes on rubber. With the new Lorain TL-10, he can now fill all of your needs! No reason now to delay—mechanize your material handling jobs today! The new TL-10 has arrived! Check it over — at your Thew-Lorain Distributor!

Now you can afford to put mobile crane power to work — even on jobs that do not warrant the investment in high production machines. Mount the new TL-10 crane on your truck—new or used—and know what it means to put your stockpile "on wheels"—what it means to profitably mechanize that multitude of material handling, lifting, loading and erection jobs that ordinarily are handled by high cost labor. Or, mount on barge, pier, dock, bin, etc. to handle materials faster — anywhere! The new Lorain TL-10 is the right size — and the right price — to fit *any* material handling problem!

The new "baby" Lorain TL-10 is a "chip-off-the-old block". It has the famous Lorain "TL" quality and fast, smooth operation. It is an off-spring of the world's first truck crane built by Thew-Lorain more than 30 years ago. The new TL-10 has a pedigree you can bank on!

THE THEW SHOVEL CO., LORAIN, OHIO

THEW LORAIN

SAVE TIME TWO WAYS

with TOLEDO SIMPACT

for all 1" to 2" threading!

Dies changed from one size to another in a few seconds. Positive, practical die setting.

QUICK CHANGE TO 4 PIPE SIZES

QUICK THREADING

ONLY ONE SET OF DIES for 4 pipe sizes.

FASTER CHANGE OF SIZES! Just push the size selector button, slip dies in proper steps, turn head slightly and die size is changed!

EXTRA RUGGED FOR EXTRA LONG LIFE . . . producing accurate threads.

EASY TO OPERATE . . . simple in design . . . fewer parts . . . light in weight.

AMAZINGLY COMPACT . . . will thread a pipe projecting through a wall as short as 6¼".

ACCURACY THROUGH THE YEARS . . . dies recede along tapered steps . . . no cams to wear.

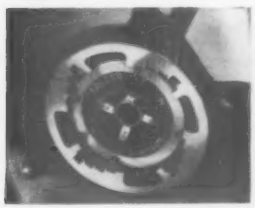
LOW COST! This remarkable self-contained tool assures smooth, perfectly tapered, leak-proof threads at lower cost! Play safe! Buy Toledo Simpacts at your dealer. The Toledo Pipe Threading Machine Co., Toledo, Ohio. New York Office: 165 Broadway, Room 1310.

50 YEARS OF LEADERSHIP

TOLEDO

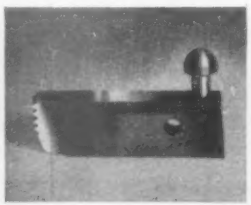
PIPE TOOLS . . POWER DRIVES
. . POWER PIPE MACHINES

AUTOMATIC DRIP OILING. Oil pockets in head of a Simpact collect oil and drip directly on dies.



3-CHUCK JAWS. Simpact pipe holder with 3-chuck jaws is easy to center, and assures perfect aligned threads.

TOLEDO SIMPACT DIES are made of high speed steel and are easily resharpened.



SIMPLE . . . COMPACT. Note the simplicity of the Simpact. No complicated cam parts to clog with dirt and wear.

Pipeline Enamel STAYS PUT... reinforced with Fiberglas Coromat

Two facts are clear from pipeline construction records. First, nothing equals *glass* for reinforcement and protection of pipeline enamel coatings. Second, more miles of pipeline coatings are protected by Fiberglas Coromat* than by any other glass wrap (over 700 million square feet in use).

Coromat is effective, because it makes the enamel effective! It draws permanently into the coating. Adds strength . . . keeps enamel on the pipe in uniform thickness. As it is wrapped on, Coromat helps to control loss of enamel, eliminates holidays by breaking gas and air bubbles. Once in place, this membrane of fine fibrous glass prevents heat sag and cold flow. It lessens damage to enamel from backfill impact, and increases resistance to soil stress 2 to 5 times.

In application, Fiberglas Coromat saves time and trouble. Parallel reinforced for fast, break-free wrapping—easy to handle, uniform in quality. Contact your nearest Fiberglas branch office for full information and prompt service. OWENS-CORNING FIBERGLAS CORPORATION, Dept. 54-K4, Toledo 1, Ohio.

For added protection
FIBERGLAS OUTER WRAP

Tough glass-and-bitumen construction—pioneered by Owens-Corning—cushions enamel against backfill shocks, soil stresses, bumps in handling. Perforated to release air and gases. Keys firmly into enamel.

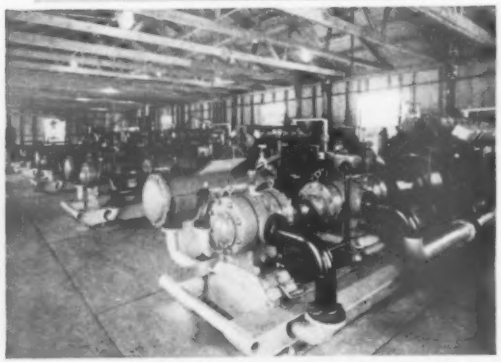
OWENS-CORNING
FIBERGLAS

ON YOUR PIPELINES . . . FOR GOOD!

*Fiberglas and Coromat are trade-marks (Reg. U. S. Pat. Off.) of Owens-Corning Fiberglas Corporation for products made of or with fibers of glass.

On the plains of Texas
In the hills of Pennsylvania

FULLER ROTARY COMPRESSORS

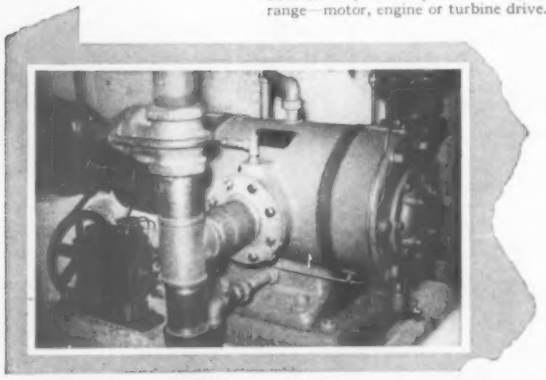


Fuller Rotary Compressors, in the refinery for general plant air, purging gas, refrigeration in alkalization units, and handling butane-butylene, as well as in the field for pressure boosting and gas gathering, have proved their worth, as is evidenced by the many machines in daily use in practically every oil-producing section of the country.

The ability of Fuller Rotaries to perform, day in and day out, with minimum attention, supervision, and maintenance, has *earned* for them a well deserved position in the oil fields. Particularly adapted to handling of weak wells, and the volume demanded, without creating a serious maintenance and supervision problem, they have proved to be an economic and practical answer for many producers.

Simplicity of construction has proved to be one of the important factors . . . the only moving parts being the rotor, bearings, blades. No valves to leak; no seats to grind, *giving full boosting capacity for the life of the machine.* A simplified direct drive eliminates power transmission losses.

Fuller Rotary Compressors are available in a range of cylinder combinations up to 3300 c.f.m. (at atmospheric intake) at normal speeds, with a reasonable variation in speed range—motor, engine or turbine drive.



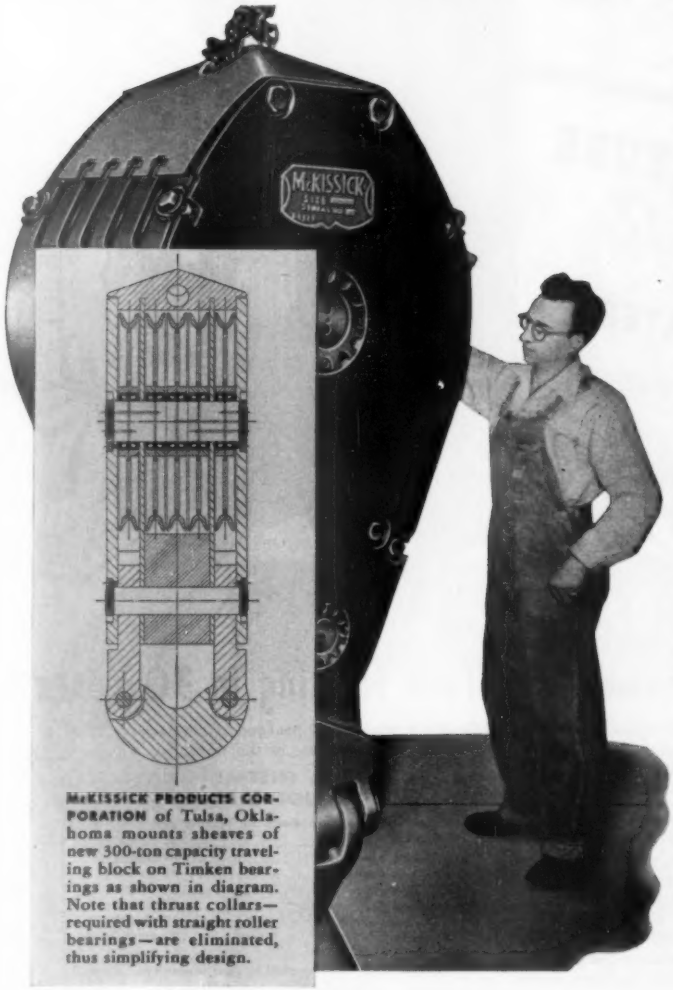
FULLER COMPANY, Catasauqua, Pa.
120 So. LaSalle St., Chicago 3
420 Chancery Bldg., San Francisco 4

Write for Bulletin C-6

C-227

Fuller PIONEERS OF HIGH-EFFICIENCY VANE-TYPE ROTARY COMPRESSORS

How they built more trips into McKissick's biggest traveling block



McKISSICK PRODUCTS CORPORATION of Tulsa, Oklahoma mounts sheaves of new 300-ton capacity traveling block on Timken bearings as shown in diagram. Note that thrust collars—required with straight roller bearings—are eliminated, thus simplifying design.

THE 300-ton capacity rating of this new McKissick traveling block means that its sheaves get a real workout every trip. To keep sheaves in proper alignment, reduce friction and wear, and insure longer block life, McKissick mounts the sheaves on Timken® tapered roller bearings.

Because Timken bearings carry both radial and thrust loads, they locate the sheaves positively, irrespective of lead of line. True rolling motion and incredibly smooth surface finish of Timken bearings virtually eliminate friction. There's no problem of uneven sheave wear, line wear or wear in the bearings.

Timken bearings insure longer life another way. They keep shafts and housings concentric, making closures more effective so dirt and moisture stay out—lubricant stays in.

As a result, even under the heaviest loads, traveling blocks equipped with Timken bearings keep operating dependably, give more years of service. Maintenance time is reduced. There's less time out for repair.

No other bearing gives all the advantages offered by Timken bearings. Specify Timken bearings in the oil field equipment you build or buy. The trade-mark "Timken" is your assurance of value. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

GREATER LOAD AREA

Because the load is carried on the *line* of contact between rollers and races, Timken bearings carry greater loads, hold shafts in line, wear longer.

The Timken Roller Bearing Company is the acknowledged leader in: 1. advanced design; 2. precision manufacturing; 3. rigid quality control; 4. special analysis steels.

NOT JUST A BALL ◯ NOT JUST A ROLLER ▭ THE TIMKEN TAPERED ROLLER ▭ BEARING TAKES RADIAL ◫ AND THRUST ↔ LOADS OR ANY COMBINATION ✳

...Greatest Improvement in Tank Heating in 30 Years

Brown Fintube Thermo-Flo Tank Heaters are more efficient, and usually *cost less plus their installation,* than the cost of just installing equivalent capacity of old fashioned bare pipe coil in the bottom of the tank.

Brown Thermo-Flo heaters mount vertically, on adjustable legs about 12″ above the tank bottom, thus preventing depositing on the tubes; and avoiding the lost efficiency of heating the tank bottom, and a layer of sediment. The bottom of the tank is uncluttered and easy to clean. The entire surface of the fintubes is exposed to the tank contents. Material adjacent to the fintubes is heated quickly and rises rapidly, forming a thermal syphon or flow past the fintubes; keeping the heating surfaces clean; assuring extremely efficient heating; and preventing any stratification of temperature or gravity in the tank.

TYPICAL INSTALLATIONS IN MAJOR REFINERIES

Purchased on the Basis of Proven Advantages

Tank Farm No. 1	81 Heaters
Tank Farm No. 2	114 Heaters
Tank Farm No. 3	76 Heaters
Tank Farm No. 4	110 Heaters
Tank Farm No. 5	51 Heaters
Tank Farm No. 6	42 Heaters
Tank Farm No. 7	294 Heaters
Tank Farm No. 8	74 Heaters

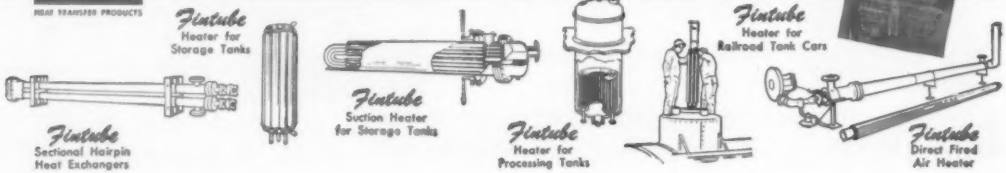
Above heaters being used to heat viscous crude oils, lubricating oils, tar, asphalt, etc.

BROWN FINTUBE CO.

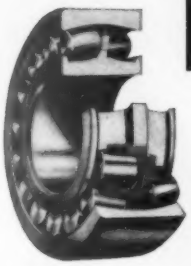
HEAT EXCHANGE SURFACE
BROWN FINTUBE
HEAT TRANSFER PRODUCTS

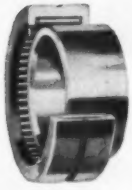
HOME OFFICE and WORKS • ELYRIA, OHIO

Send for Bul. No. 491
IT WILL GIVE YOU IDEAS



no axe to grind





Since Torrington makes every basic type of anti-friction bearings, our engineers are able to make impartial recommendations for the type best suited to your needs.

Perhaps your application calls for spherical roller bearings. Maybe tapered roller, straight roller, ball or needle bearings are what you need. Or, Torrington can design a special bearing, tailored to your requirements.

In short, whatever your friction problem, there's a Torrington bearing to solve it. Why not ask us to help you?

THE TORRINGTON COMPANY

South Bend 21, Ind. Torrington, Conn.

District Offices and Distributors in Principal Cities of United States and Canada

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Straight Roller • Needle • Ball • Needle Rollers

Best Buy

...Here's Why!

Aeroquip Detachable, Reusable Fittings reduce hose line inventory. For on-the-spot replacements cut bulk hose to required length and attach fittings.

Unique Fitting design provides quick, easy assembly and assures positive grip on hose. No adjusting is required after assembly.

Hose is constructed of seamless synthetic rubber compound reinforced with two cotton braids and a high tensile steel wire braid.

Wide range of male and female end fittings in all sizes meet practically every requirement. Fittings are designed to SAE and JIC specifications.

Tough, durable Aeroquip Hose Lines are fire resistant. They perform satisfactorily at extreme temperatures—from —40° to +275° F.

Aeroquip Hose Lines are widely used with hydraulic fluids, lubricants, water, gasoline, Diesel fuel, air, and many other fluids.

A lways first

AEROQUIP FLEXIBLE HOSE LINES OUTSELL ALL OTHERS
FOR INDUSTRIAL AND AIRCRAFT APPLICATIONS

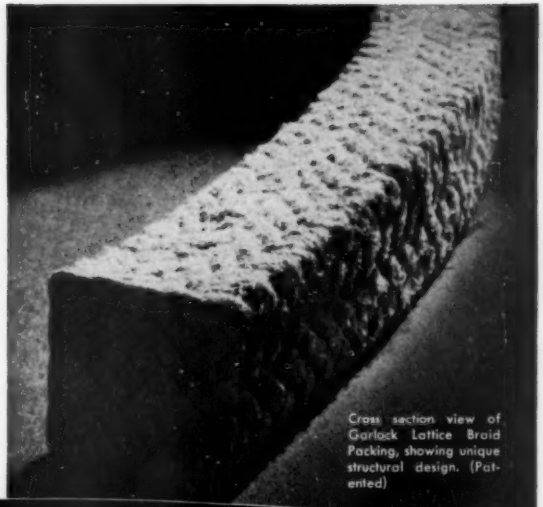
Aeroquip

AEROQUIP CORPORATION, JACKSON, MICHIGAN

SALES OFFICES: BURBANK, CALIF. • DAYTON, OHIO • HAGERSTOWN, MD. • HIGH POINT, N. C. • MIAMI SPRINGS, FLA.
MINNEAPOLIS, MINN. • PORTLAND, ORE. • WICHITA, KAN. • TORONTO, CANADA

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

For Long Trouble-Free Service USE



Cross section view of Garlock Lattice Braid Packing, showing unique structural design. (Patented)

LATTICE-BRAID PACKING

GARLOCK 751 (cotton) Lattice-Braid Packing for hot or cold water.

GARLOCK'S specially designed Lattice-Braiding machines.

The Greatest Improvement Ever Made in Braided Packings!

The strands of Garlock Lattice-Braid packings are braided *through* and *through* on specially designed braiding machines. Since all strands are strongly linked together into a single unit, they are firmly held together even when the packing is worn far beyond the limits of wear of ordinary braided packings.

This exclusive lattice braiding also provides unusual flexibility and semi-automatic pressure action which keeps the packing properly adjusted in the stuffing box. Longer service with less attention.

Garlock Lattice-Braid is manufactured from flax, cotton, asbestos, wire-inserted asbestos and "Teflon"—for various types of service. Furnished in ring, coil or on reels.

Write today for the new Lattice-Braid Folder.

THE GARLOCK PACKING COMPANY
PALMYRA, NEW YORK

Tulsa, Okla. Houston, Tex.
Los Angeles, Calif.

GARLOCK

PACKINGS, GASKETS, OIL SEALS,
MECHANICAL SEALS,
RUBBER EXPANSION JOINTS

Kean Archives

PIPE WITH THE YEARMARK

DO YOU KNOW THE DATE?

Date of freedom—date to remember! 1620, the landing of the Pilgrims opened a new era in human rights. Their voyage was long, perilous, filled with hardships—but it marked the New World as a land of hope.

When you next order steel pipe be certain to specify WHEATLAND, the pipe with the Yearmark. It is your assurance of quality inside and out. The date, welded into each length is a mark of pride . . . a date to remember.

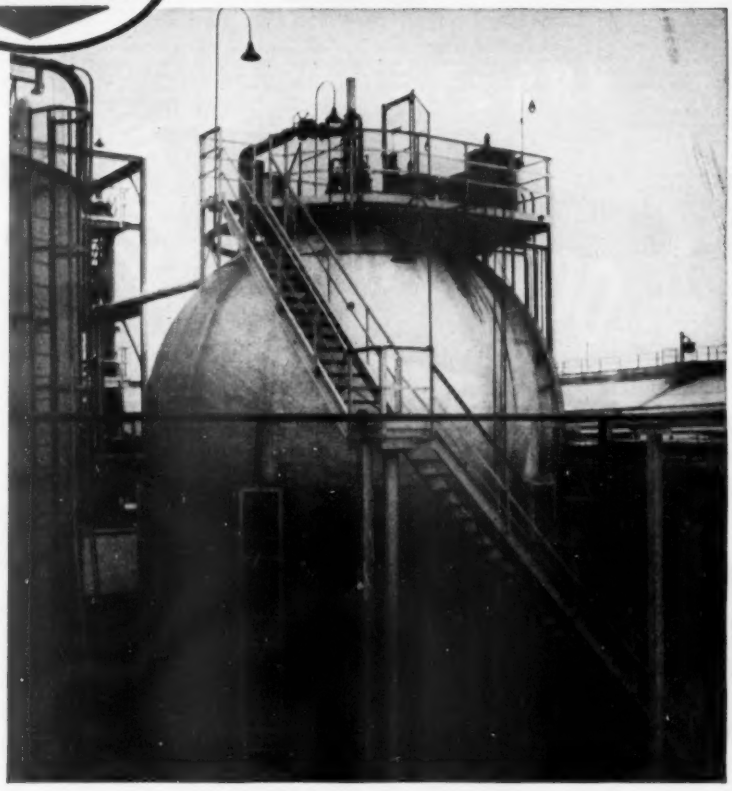
WHEATLAND TUBE COMPANY

BANKERS SECURITIES BUILDING, PHILADELPHIA 7, PA.

Scrap is urgently needed to help keep America strong and free. Do your part — *get in your scrap today!*

SOHIO

another leading refiner who desalts with PETRECO



The Standard Oil Company of Ohio is a long-time user of Petreco Electric Desalting. Like many other oil industry leaders, Sohio installed a Petreco desalting plant in one refinery, then repeated with Petreco in another.

The merit of a refining process often can be appraised by the caliber of the refining organizations who install, use and re-order. Petreco invites you to check into the large number of leading refiners who, like Sohio, use Petreco Electrospheres.

For descriptive literature and complete information on Petreco desalting, call or write

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PETRECO DIVISION

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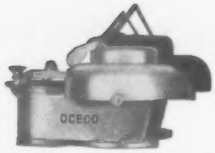
PETRECO

ELECTRIC PROCESSES FOR THE PURIFICATION OF PETROLEUM

CRUDE OIL: **REMOVAL OF SALTS, SOLIDS AND OTHER IMPURITIES; DEHYDRATING**
DISTILLATES: **ACID, CAUSTIC AND DOCTOR TREATING**
FUEL STOCKS: **DESAPONIFICATION**

PR 52-4



V-113 VENT VALVES control tank breathing, minimizing vapor losses and deterioration of product. High flow capacity, 2" to 12" sizes. ½ oz. to 8 oz. pressure or vacuum settings.

GAUGE HATCHES provide a gas tight closure for gauging, sampling and taking temperature readings. Pedal type hatch opens with a natural straight downward foot movement. Flanged or screw mounting. Also clamping cover type for pressures from 2 oz. to 15 lbs.

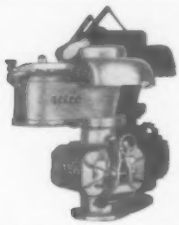
V-114 INTERNAL TANK VALVES are provided with a fusible link that melts when subjected to fire, closing the valve instantly, and cutting off the flow from the tank. 3", 4", 6", 8" and 10" sizes.

TYPE "E" FLAME ARRESTORS can withstand long exposure to fire. The "banks" have vertical straight through passages—minimizing entrainment and pressure drop, and are "extensible" for easy cleaning. 2" to 10" sizes.

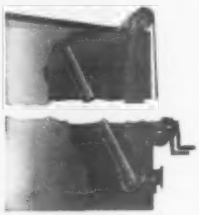
OCECO FITTINGS

Prevent VAPOR AND FIRE *Losses*

V-108 EMERGENCY PRESSURE RELIEF VENTS provide instant relief for excessive internal pressures, resulting from exposure fires, etc. Furnished in 6", 8", 10", 15¼" and 20½" sizes.



TYPE "BE" VENT UNITS consist of a V-113 Vent Valve with snuffer, mounted on a Type "E" "Extensible" Bank Flame Arrestor. 2" to 10" sizes. Unsurpassed for efficiency and reliability.



SWING LINE EQUIPMENT—complete facilities including heavy duty tank nozzle; efficient double elbow swing joint; swing pipe; cable clamp; cable; sheave bracket and internal or external winch.

WATER DRAW-OFF VALVES for drawing water from the bottom of storage tanks. Unique double valve construction permits the valve chamber to be drained to prevent freezing, and the working valve serviced without emptying tank. 2" x 1½"; 3" x 2" and 4" x 3" sizes.

● Oceco Vents eliminate the free discharge of vaporized liquids. They control tank breathing resulting from temperature changes and pumping – protect the quality of the stored product – and prevent "blow-outs" and "cave-ins". Oceco Flame Arrestors are a positive flame stop – they prevent explosions and fires.

Specify Oceco Fittings *throughout* for *all* your tanks – and get proven, dependable, trouble-free protection for only a fraction of one per-cent of the value of the tank and its contents.

A few of the most popular Oceco fittings are illustrated and described briefly herewith. But send for the Oceco Data Sheets. They give full details and specifications, and complete listings of sizes, weights, dimensions, etc. Let the Oceco Engineers – pioneers in this work – help you equip your tanks for utmost safety and economy.

SEND FOR THE OCECO DATA SHEETS. Ask for sheets on the individual fittings in which you are most interested, or send for the complete set. WRITE TODAY.

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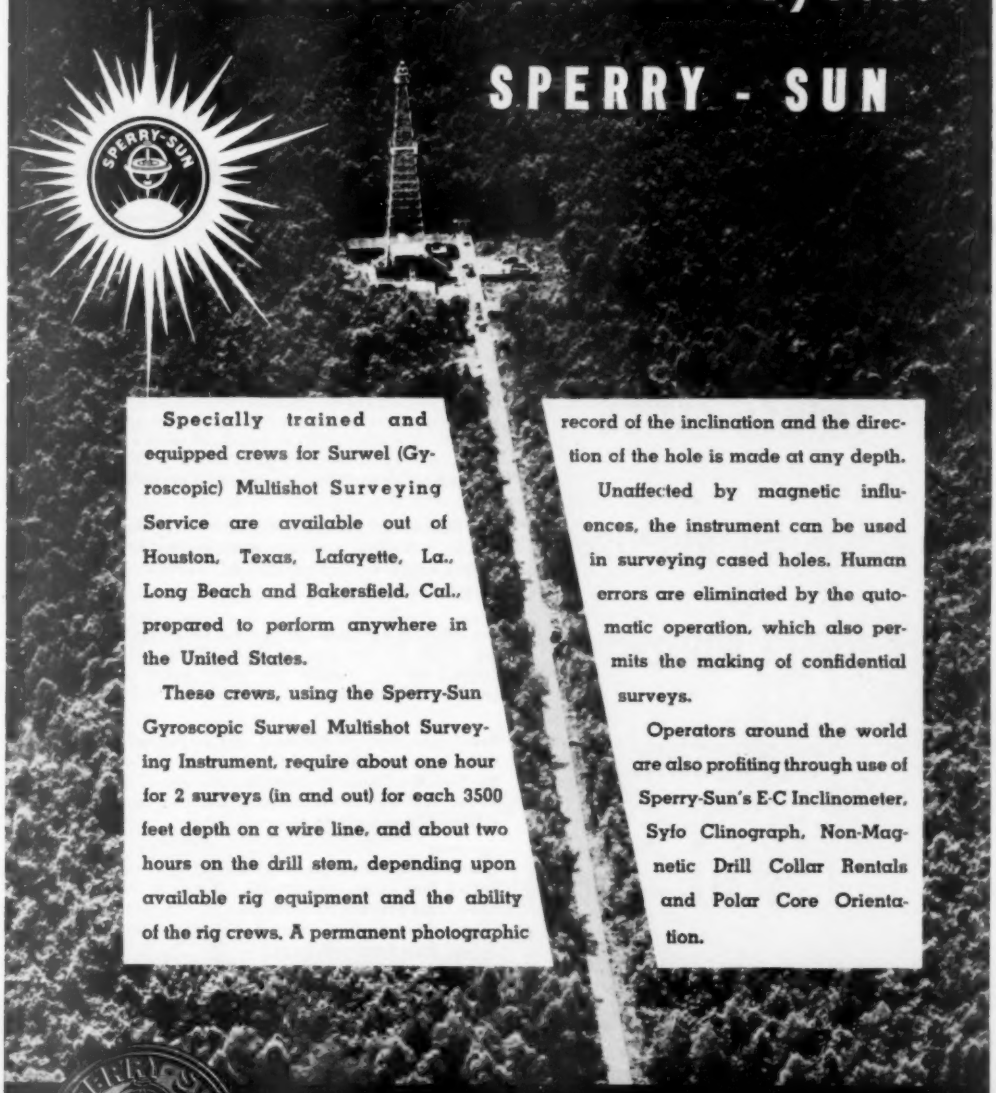

Specially trained and equipped crews for Surwel (Gyroscopic) Multishot Surveying Service are available out of Houston, Texas, Lafayette, La., Long Beach and Bakersfield, Cal., prepared to perform anywhere in the United States.

These crews, using the Sperry-Sun Gyroscopic Surwel Multishot Surveying Instrument, require about one hour for 2 surveys (in and out) for each 3500 feet depth on a wire line, and about two hours on the drill stem, depending upon available rig equipment and the ability of the rig crews. A permanent photographic record of the inclination and the direction of the hole is made at any depth.

Unaffected by magnetic influences, the instrument can be used in surveying cased holes. Human errors are eliminated by the qutomatic operation, which also permits the making of confidential surveys.

Operators around the world are also profiting through use of Sperry-Sun's E-C Inclinometer, Syfo Clinograph, Non-Magnetic Drill Collar Rentals and Polar Core Orientation.

SPERRY-SUN WELL SURVEYING COMPANY

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FOR PRODUCERS

AND REFINERS

OIL PROBLEMS INVOLVING

EMULSIFICATION

WASTE OIL DISPOSAL

SALT FOULING

CORROSION

SCALE

PARAFFIN

Having specialized in the production of petroleum emulsion-breaking chemicals longer than any other organization, the Tretolite Company offers a wealth of service know-how and a background of research effort which insures a quick and economical solution for your emulsion problems.

The disposal of waste-oil and oil-bearing waste waters can result in serious stream pollution problems. Tretolite offers advisory service and an effective line of oil-in-water demulsifiers.

The efficient extraction of harmful salts from refinery charging stocks by the use of chemical demulsifiers has been carried on by Tretolite for many years. Ask about the complete Tretolite desalting service.

Every year, both in the field and in the refinery, corrosion takes a costly toll in metal equipment destroyed. KONTOL, the Tretolite Company corrosion inhibitor, is applicable both in the field and in the refinery, and can already cite many effective case histories of protection.

Effective prevention can stop many costly scale accumulations before they cause operational difficulties. The Tretolite S.P. chemicals prevent adherence of scale-forming inorganic solids on the working surfaces of pumps, pumping equipment, valves, flow lines and traps.

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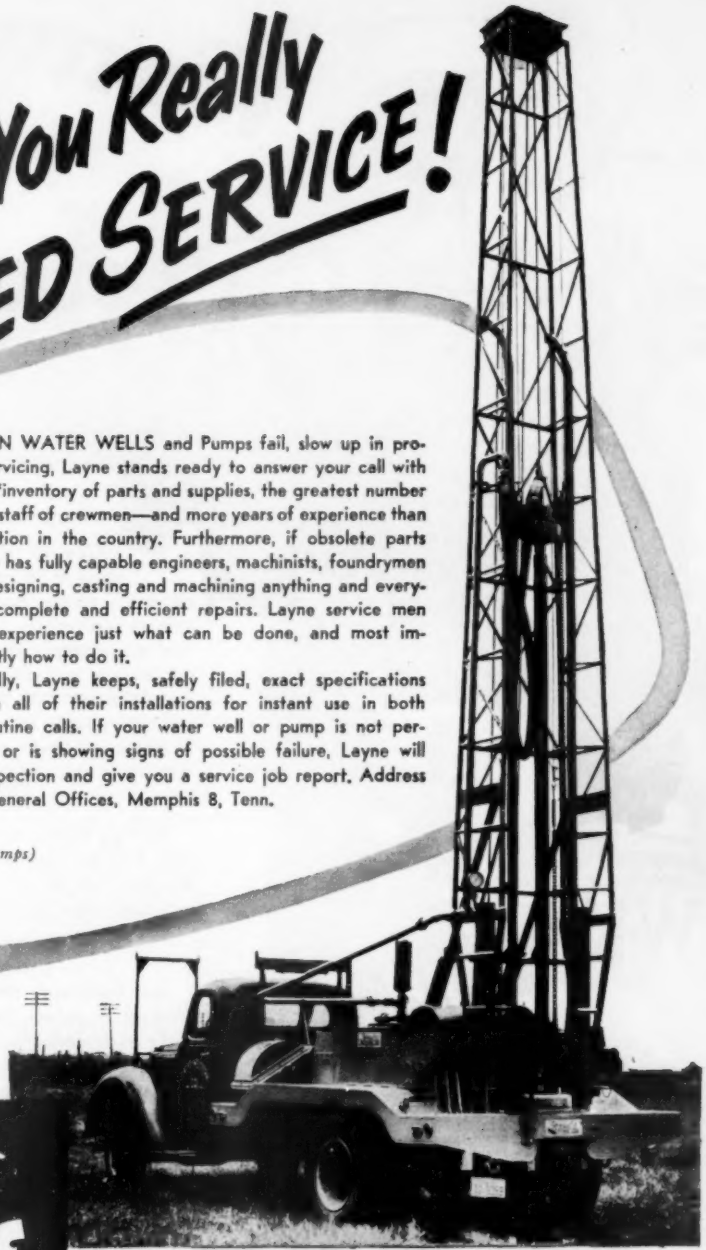
WHEN WATER WELLS and Pumps fail, slow up in production or need servicing, Layne stands ready to answer your call with the world's largest *inventory of parts and supplies, the greatest number of rigs, the biggest staff of crewmen—and more years of experience than any other organization in the country. Furthermore, if obsolete parts are required, Layne has fully capable engineers, machinists, foundrymen and factories for designing, casting and machining anything and everything needed for complete and efficient repairs. Layne service men know from actual experience just what can be done, and most important of all, exactly how to do it.

Advisedly, Layne keeps, safely filed, exact specifications and full details on all of their installations for instant use in both emergency and routine calls. If your water well or pump is not performing efficiently or is showing signs of possible failure, Layne will gladly make an inspection and give you a service job report. Address Layne & Bowler, General Offices, Memphis 8, Tenn.

*(*for all makes of pumps)*



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One of the toughest jobs for a refinery valve is in hot fluid catalyst cracking slurry oil lines, where operating temperatures hit 900°. W-K-M Valves up to 16" are used in this service and many other refinery applications with outstanding success, including propane-deasphalting and fuel manifolds. W-K-M Valves have built unusually long service records in thermal cracking units at high pressures and temperatures up to 1050° F.

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W-K-M Valves have proved their worth in Christmas Tree and related services as is demonstrated by the fact that 80% of the world's high pressure wells are controlled by W-K-M Valves.

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An important development has been made by W-K-M in valves for handling propane and other light hydrocarbons. The basic design of the W-K-M Process Valve has been retained, and Teflon inserts are swaged into the regular seat replacing the combination wiper and seal ring. In normal daily operation, the Teflon insert serves as the seat. In case of fire, which might damage the Teflon seats, the steel seats will remain in service.

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You'll find W-K-M Valves from 2" to 30" in sour crude lines, gas lines and gasoline lines. They are operated by hand wheels, motor operators, air cyl-

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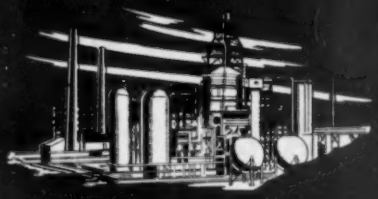
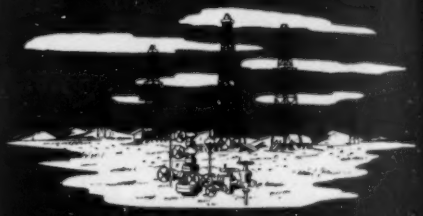
This new W-K-M Catalog is yours for the asking. It explains all the design, construction and operational features of W-K-M.

are tough valve jobs

W-K-M

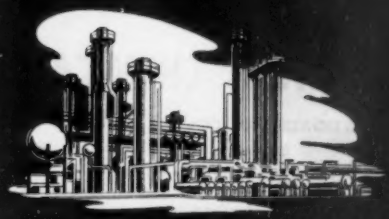




inders, controlled by radio. No other valve will handle so many pipeline jobs so well, so efficiently and for such a long time between installation and first maintenance.

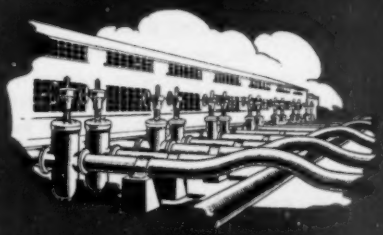
CHEMICAL PROCESSES

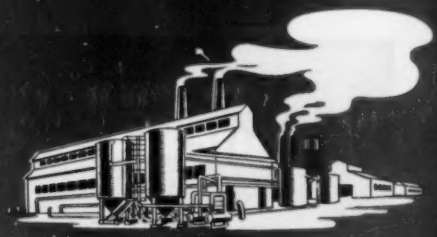
Hydrochloric acid, chlorine gas, ethylene gas, ethyl and isopropyl alcohols are among the products efficiently handled by W-K-M Valves. More and more W-K-M Process Valves are being installed in process plants because of their extraordinary ability to cope with the unique conditions of operations called for in processing plants. Take the case of highly-taxed ethyl alcohol, for instance, where minor packing leaks and product contamination cannot be tolerated. W-K-M Process Valves fit the application perfectly as illustrated by the growing number of them being ordered for this service.



W-K-M DESIGN AND CONSTRUCTION

W-K-M Valves are precision made with features of design, construction and performance which set them far above ordinary valves. You'll find W-K-M on the tough jobs.You'll find them doing a good job where other valves have failed. Why not look to W-K-M Valves to solve your valve problems. It's only logical when they handle the tough jobs so well, they'll give better service, longer life with less maintenance on any valve job. Send for W-K-M Catalog No. 700-52 and specify whether you need Production Valves, Pipeline Valves or Process Valves.





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. . . the new Petrol "ERO" Blue goes further and meets today's aviation gasoline specifications . . . also available is the original aviation gasoline dye, Petrol PC Blue, which for more than 20 years was the standby coloring agent for aviation gasolines . . . inquiries are invited for the new "ERO" Blue and for the old Petrol PC Blue for coloring aviation gasolines.

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for gasoline, kerosene, diesel and tractor fuels . . . Bronzes, Ambers, Blues, Greens, Golds, Yellows, Purples, Oranges, Reds, Browns, Blacks.

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. . . inhibitors for gasoline, oils, rust . . . high pressure lubricants, stabilizers, emulsifiers, detergents, wetting agents, dispersing agents.

PETROL BLUE WHITENER R and B
are used to neutralize undesirable yellow shades in uncolored gasoline or kerosene.

DEBLOOMING AGENT A
has the property of neutralizing blooms in lubricating oils.

N. P. A. COLOR
has the property of changing body color of pale oils to red cast, without affecting natural fluorescence.

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6 Good Reasons Why...

...IT'S WISE TO STANDARDIZE with WECO

1. THE RIGHT UNION FOR EVERY SERVICE

WECO has a size and pressure union that seals and holds in every oil industry service. Standardizing with WECO means you can put the right union in the right place for maximum service and performance.

2. COMPLETE INTERCHANGEABILITY

All WECO Unions in the same size and pressure range can be interchanged with complete assurance of a leak-proof seal. This is a great time and money saver on lines that are made-up and broken out repeatedly.

3. PRECISION MANUFACTURING

WECO pioneered the design and manufacture of Acme thread wing nut unions for the oil industry. For more than 18 years its engineering and plant facilities have been devoted to the development and improvement of wing nut unions with the result that WECO's "Most complete line of wing unions in the world" are also leaders in service, long life and economy.

4. AT SUPPLY STORES EVERYWHERE

Wherever there's an oil field and a supply store, there's an ample stock of WECO Unions in the sizes and pressures most generally used in your locality. Your supply store knows the equipment in greatest demand . . . that's why you'll find the WECO Union you want—wherever you are.

5. PERFECT SEALING

WECO'S famous Ball-and-Cone seat provides high unit loading and unequalled sealing ability. It makes possible the interchangeability and simplicity of WECO Unions which seal perfectly when made-up by hammer blows or an ordinary bar.

6. LONGER LIFE, LOWER COST

WECO Unions have the strength and toughness to withstand distortion, vibration, shock, high surge pressures and other rough, tough oil field service. All parts are made of selected, heat-treated materials, subs have thicker wall sections and nuts have heavy Acme threads.

FIG 100
1000 p.s.i. TEST
SIZES: 2", 2½", 3", 4", 6", 8"

FIG. 200
2000 p.s.i. TEST
SIZES: 1", 1¼", 1½", 2", 2½"
3", 4", 6", 8"

FIG 400
4000 p.s.i. TEST
SIZES: 2", 2½", 3", 4", 5½" O.D.,
6", 7" O.D., 8", 10"

FIG 600
6000 p.s.i. TEST
SIZES: 1", 1½", 2", 2½", 3", 4"

FIG. 602
6000 p.s.i. TEST
SIZES: 1", 1½", 2", 3", 4"

FIG 1502
15,000 p.s.i. TEST
SIZES: 2", 2½", 3"

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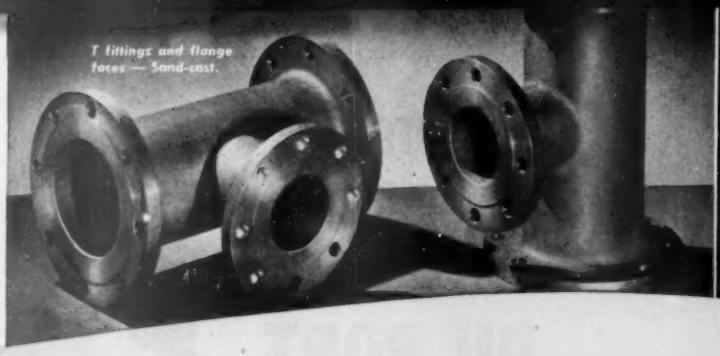
Heat Exchangers of

Downingtown Iron Works, Inc.

These two exchangers, fabricated by Downingtown Iron Works, Inc., Downingtown, Pa., are used in condensing benzene. Ampco Metal Tube sheets are welded to a steel shell and the heads, also made from Ampco Metal, are welded to steel flanges. All welding is done with Ampco-Trode® electrodes. Shell diameter 14". Tube length 10 feet.

The Whitlock Manufacturing Co.

This 4-pass exchanger was fabricated by The Whitlock Manufacturing Co., Hartford, Connecticut. The service is product cooling, with river water as the cooling medium. Channel cover — steel, lined with Ampco Metal Grade 8. Channel, including flanges — Ampco Metal Grade 8. Tubes — 1323 sq. ft. — ¾" OD x 16 BWG x 16'-0" Ampco Metal Grade 8. Physical construction — Whitlock Type 4-ST-4 straight tube floating head (split-ring assembly design). Shell diameter — 27 inches ID.



T fittings and flange faces — Sand-cast.

Valve bodies — Sand-cast.

AMPCO* METAL

resist corrosion and erosion

YOU can get better service from your heat exchangers, when you use Ampco Metal for those parts that are subjected to attack by corrosion or erosion.

But heat exchangers are not the only application for Ampco Metal. You find it used in many places in the process industries and in marine service as well . . . for tanks, pipe, separators, bubble caps, fractionating towers, stills, condenser water boxes, agitators, etc. — wherever you need high resistance to corrosion and erosion.

Ampco Metal Grade 8, one of the Ampco series of engineered aluminum bronze alloys, is Boiler Code approved for unfired pressure vessels. In addition, you get these unique properties: high resistance to corrosion . . . high tensile (75,000 psi) . . . high physicals at extreme temperatures . . . high strength to weight ratio . . . high impact and fatigue values (Charpy @-423° F., 93 ft. lbs.; @ 70° F., 75 ft. lbs.; fatigue limit 28,000 lbs. @ 100,000,000 cycles) . . . high resistance to wear from erosion, abrasion, cavitation pitting . . . high compressive strength (E. L. in Comp. 25,000 psi) . . . high modulus of elasticity (18,000,000).

Moreover, Ampco Metal Grade 8 is easy to fabricate with Ampco-Trode* welding wire, rods, or covered electrodes. And, Ampco Metal Grade 8 is available in a variety of forms — sheet, plate, extrusions, pipe, tubes, fasteners, etc. Since it is the answer to many problems, it may help you. Consult your nearest Ampco Field Engineer or write us for further information.

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Fabricating Ampco Metal with Inert Gas Consumable Electrode welding.

*Reg. U. S. Pat. Off. Ampco Metal, Inc., Milwaukee, Wisconsin

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PR-8

LANE WELLS "Koneshot" process insures maximum penetration with

DU PONT JET PERFORATORS

The Lane-Wells organization (Los Angeles), operating seventy-one domestic branches, and subsidiaries in Canada and Venezuela, is the oldest specializing in oil-well perforation.

Well aware of the importance of deep penetration, Lane-Wells offers customers "plus-value" shaped charge perforating with Du Pont Jet Perforators. They recognize that deeper penetration into the producing formation promotes greater productivity and can mean the difference between a paying well and a dry hole.

Every perforating job presents obstacles. Casing may be eccentric within the well bore. A caving formation in the producing zone may result in cement sheaths of doubtful thickness. Drilling mud filtrate may have permeated the formation and blocked the producing zone.

Surest way to overcome obstacles of this kind is to use perforating tools that give maximum penetration. That is why Lane-Wells recommends and uses Du Pont Jet Perforators.

Laboratory tests, periodically repeated, have assured Lane-Wells engineers that Du Pont Jet Perforators consistently give greater penetration—through one, two, or even three strings of casing—and at temperatures up to 350°F.

When you're next in the market for perforating service . . . you can be sure you'll get maximum penetration by specifying that Du Pont Jet Perforators be used on the job. And you'll be saving money in the long run. Ask the Du Pont representative in your area for complete information or write: E. I. du Pont de Nemours & Co. (Inc.), Explosives Dept., Wilmington 98, Delaware.

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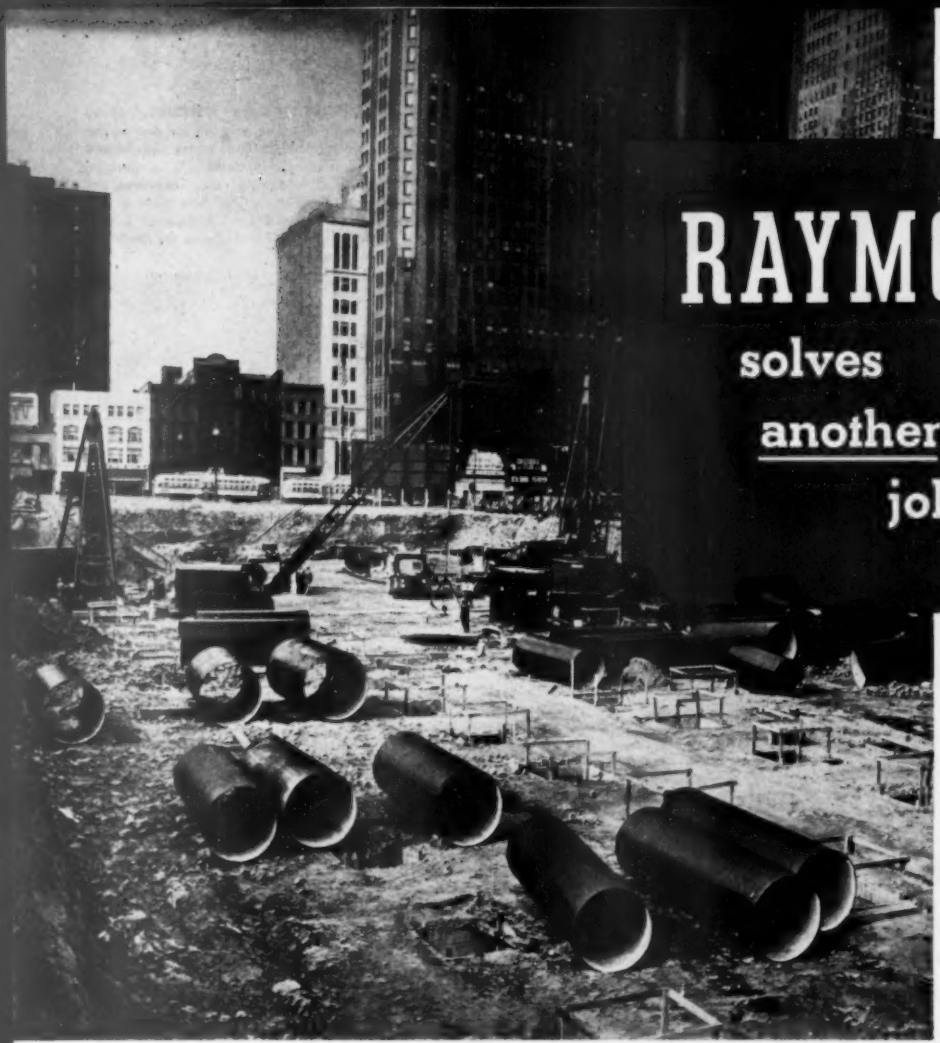

RAYMOND

solves another tough job!

at left
Sinking Gow caissons for Detroit's City-County Building

FOUNDATION CONTRACTOR:
O. W. Burke Co.

ARCHITECTS & ENGINEERS:
Harley, Ellington & Day, Inc.

CONSTRUCTED FOR:
Detroit-Wayne Joint Building Authority

...To provide the foundation for the City-County Building in Detroit's new Civic Center, Raymond placed 126 Gow caissons, with diameters of 48 to 74 inches, to depths exceeding 100 feet to hardpan. The caissons were belled out on the hardpan to varying diameters. Completion of this project ahead of schedule is another example of how Raymond engineers combine knowledge and experience with specially designed equipment to provide any type foundation anywhere. We would like to serve you on your next project.

RAYMOND CONCRETE PILE CO.

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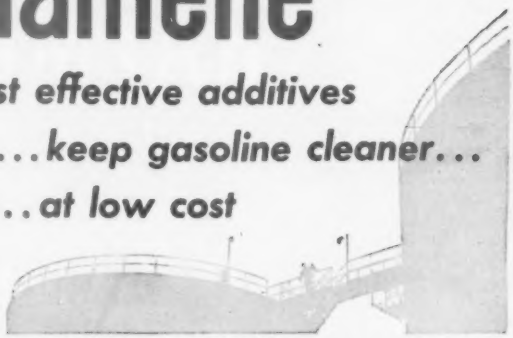
Foundation Construction . . . Harbor and Waterfront Improvements . . . Soil Investigations . . . In-Place Pipe Lining . . . Specialized Construction.

Tenamene

the most effective additives known... keep gasoline cleaner... longer... at low cost



WHAT IS GUM? Gum is a non-volatile material resembling varnish or lacquer. Soluble in gasoline, gum separates only when gasoline evaporates, unless highly concentrated. Sometimes gum settles as a heavy, dark-brown oil. The enemy of engine efficiency, gum coats carburetors, plugs jets and screens, and causes valves to stick.

WHAT INHIBITORS DO. Commercial gasoline inhibitors retard oxidative deterioration, the first step in gum formation. To prevent storage loss, inhibitors should be soluble in gasoline but not in water. They should not color gasoline and should resist darkening.

THE TENAMENES — EASTMAN INHIBITORS. For years Eastman has made the most effective gum inhibitors known—Tenamene 1 and Tenamene 2. Formerly these were sold through another company under another name. Now Eastman makes them available directly and from convenient stocks. Choice between the two gum inhibitors depends on a number of factors, such as the crude, the treatment and possible caustic carryover. Tenamene 2 should be used where traces of caustic are present. Where caustic is not present, choice must be based on such tests as ASTM Gum, Oxygen Bomb or Copper-dish Gum. Since Tenamene 2 is more concentrated and non-inflammable, its slightly higher cost is frequently more than offset by lower shipping costs.

FOR MOTOR FUELS. Tenamene 1 is a mobile, tan liquid composed of 48% N-n-butyl p-aminophenol in isopropanol. 5 to 52 lbs. per 1000 bbls. inhibit gum in most motor fuels, protect dyes from fading, and retard tetraethyl lead decomposition.

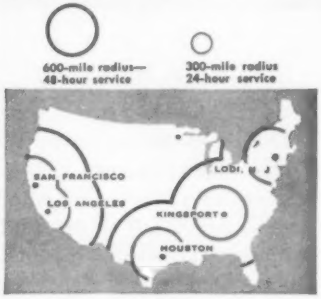
FOR MOTOR FUELS AND ALL AVIATION GASOLINES. Tenamene 2 is a mobile tan-to-red liquid comprising N,N'-di-sec-butyl p-phenylenediamine. For motor fuels generally, 2.6 to 26 lbs. per 1000 bbls. are used. Tenamene 2 has been thoroughly tested in aviation gasolines and approved for military purposes. It is highly resistant to extraction by water and caustic solutions. In hot, humid climates Tenamene 2 greatly retards deterioration of aviation gasoline that results in lead deposits. The maximum concentration allowable in aviation gasolines (8.4 lbs. per 1000 bbls.) should be added.

FOR COPPER CONTAMINATION. Tenamene 60, third member of the Tenamenes, is a mobile, red liquid composed of 80% disalicylal propylene di-imine in toluene. Traces of copper are often found in gasoline—from treating processes or from copper equipment employed during production, storage or use. Tenamene 60 overcomes the catalytic effect of copper on the oxidation stability of gasoline.

TESTS PROVE TENAMENE EFFECTIVE. Various tests with all types of gasoline proved the effectiveness of the Tenamenes. Uninhibited gasoline deteriorated rapidly in storage, forming considerable gum. Tenamene stabilized gasoline formed little gum in prolonged storage. Tennessee Eastman will be glad to make these analyses on any refiner's gasoline.

HOW TO USE TENAMENE. In general, unrefined cracked gasoline should be treated with Tenamene promptly after condensation. Refined gasoline should be treated as it is pumped to storage. If delay is necessary, add small amounts initially, the balance later. Tenamenes can be added in concentration, but are better added as dilute stock solutions since small quantities are generally involved. Common procedures are the proportioning pump, eductor or gas-pressure method. Tenamene 1 and 2 should be protected from air to prevent discoloration. Tenamene 60, however, does not need inert atmosphere for application.

WHERE CAN YOU GET TENAMENE? Eastman can give top service on your requirements of these excellent additives. Stocks of Tenamene are carried at five convenient locations. A glance at the map below shows delivery schedules. Write to one of our sales representatives* or to Kingsport, Tennessee for prices, specifications, and other information.



Tenamene

EASTMAN GASOLINE ADDITIVES

SALES REPRESENTATIVES: New York—260 Madison Ave.; Framingham, Mass.—7 Hollis St.; Cleveland—Terminal Tower Bldg.; Chicago—360 N. Michigan Ave.; St. Louis—Continental Bldg.; Houston—412 Main St. **West Coast: Wilson Meyer Co.,** San Francisco—333 Montgomery St.; Los Angeles—4800 District Blvd.; Portland—520 S. W. Sixth Ave.; Seattle—821 Second Ave.

Remember—the trade marks "tt" and "TUBE-TURN" are applicable only to products of **TUBE TURNS, INC.**

Engineered for extra strength

An important value you get with TUBE-TURN Welding Fittings and Flanges is extra strength . . . at no extra cost.

For example, this TUBE-TURN Welding Tee will withstand more pressure than required by standard codes . . . because it is drawn from seamless tubing to a barrel shape, and because of its generous crotch radius and thickness. Bursting pressures obtained in tests of representative fittings have averaged more than 25% higher than code requirements.

For this extra quality get in touch with your nearby TUBE TURNS' Distributor. You'll find one in every principal city.

Scrappy says: "Aid defense—more scrap today . . . more steel tomorrow."

Write Dept. J-11 for free booklet on Pipe Line Welding Fittings. Use coupon on reverse side.

Be sure you see the double "tt"

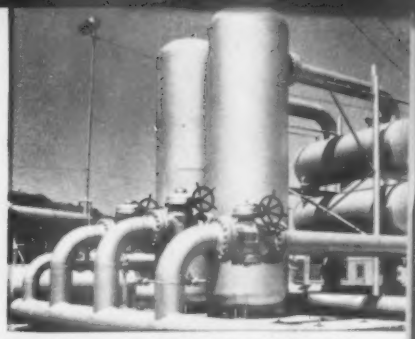
TUBE TURNS, INC. LOUISVILLE 1, KENTUCKY

DISTRICT OFFICES: New York • Philadelphia • Pittsburgh • Chicago • Houston • Tulsa • San Francisco • Los Angeles
TUBE TURNS OF CANADA LIMITED, CHATHAM, ONTARIO . . . A wholly owned subsidiary of TUBE TURNS, INC.

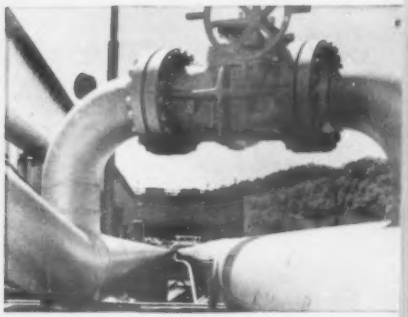
Efficient compressor station piping uses TUBE-TURN Welding Fittings

The Ohio Fuel Gas Company is known not only for efficient service, but also for its extensive underground storage facilities. In severe weather the company supplies as much as 45% of demand from 625 specially built storage wells.

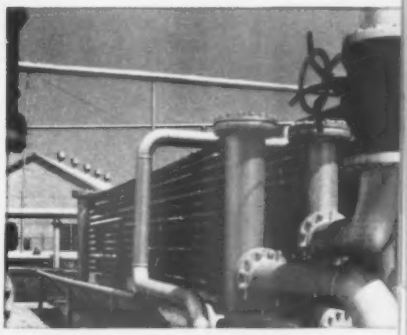
Round-the-clock dependability is maintained by welded piping systems using TUBE-TURN Welding Fittings and Flanges. Here, at Crawford Station in Columbus, piping joints are tight and secure, and maintenance is reduced to a minimum.



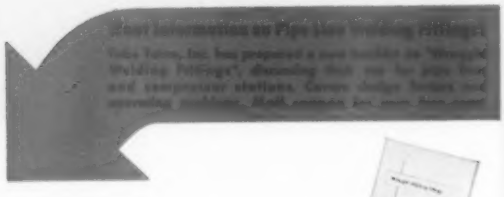
Piping fabrication was simplified by availability of the wide range of TUBE-TURN Welding Fittings and Flanges. All necessary components for complex jobs can be obtained from one reliable source . . . since Tube Turns, Inc. offers the world's broadest line of welding fittings and flanges, covering over 4000 different items.



Pressures of 800 p.s.i. are handled safely by welded 20-inch crossover line. Use of TUBE-TURN Welding Elbows and Flanges makes joints permanent and leak-proof, also keeps flow resistance and pressure drop to a minimum.



Piping for gas coolers was fabricated smoothly although lines are fitted closely together. True circularity and uniform wall thickness of TUBE-TURN Welding Fittings assure proper fit and simple alignment . . . saving time in construction.



TUBE TURNS, INC., Dept. J-11
224 East Broadway, Louisville 1, Kentucky

Your name .....

Position .....

Company .....

Nature of business .....

Address .....

City ..... *State* .....

DISTRICT OFFICES

New York	Houston
Philadelphia	Tulsa
Pittsburgh	San Francisco
Chicago	Los Angeles

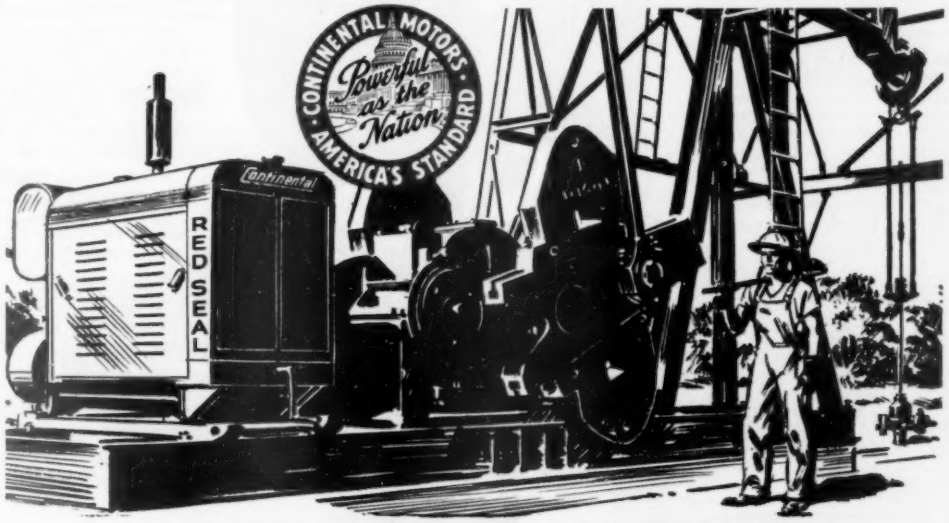
"tt" and "TUBE-TURN" Reg. U. S. Pat. Off.

TUBE TURNS, INC.

LOUISVILLE 1, KENTUCKY

MORE AND MORE OF THE WORLD'S WORK DEPENDS ON CONTINENTAL POWER

Whether or not a piece of power equipment turns out to be a "good buy" depends in large degree on the skill with which the engine is matched to the rest of the machine. That is why it's wise, when buying such equipment, to choose one of the leading makes—a make with Red Seal power. In that way, you get an engine which is not only tailored to its job, but backed by specialized experience dating from 1902.



PARTS AND SERVICE EVERYWHERE

Continental Motors Corporation
MUSKEGON, MICHIGAN

6218 CEDAR SPRINGS ROAD, DALLAS 9, TEXAS • 3817 S. SANTA FE AVE., LOS ANGELES 58, CALIFORNIA

How new AMERICAN Dri-Flo Orifice Meters Simplify Instrument Shop Maintenance

DRI-FLO Orifice Meters are advance designed to simplify instrument shop maintenance. Periodic inspection, calibration, cleaning, tear-down and assembly are done with standard tools by competent instrument men. Highly skilled specialists and elaborate equipment are not required.

The new DRI-FLO Orifice Meters — built in American Meter Company's century-old tradition for "Sustained Accuracy at Lower Cost" — bring American Westcott precision accuracy, dependability, and low maintenance to applications where mercury manometers are not desired. Available in 50", 100" and 200" ranges, working pressures to 1000 P.S.I., ambient temperatures of −25° to 175°F.

CHECK THESE OUTSTANDING TIME SAVING, LABOR SAVING ADVANTAGES...

EASE OF INSTALLATION
Pedestal, panel or overhead hanger mounting; top or bottom gage line connections. No precise levelling, no seal pots required.

ONE PIECE STAINLESS STEEL BELLOWS
Minimizes metal fatigue for long service life. Easily filled with fluid in the instrument shop without elaborate equipment.

NO STUFFING BOX LUBRICATION
American Type "B" Teflon Seal Stuffing Box is self-lubricating; eliminates shaft freezing and leaks.

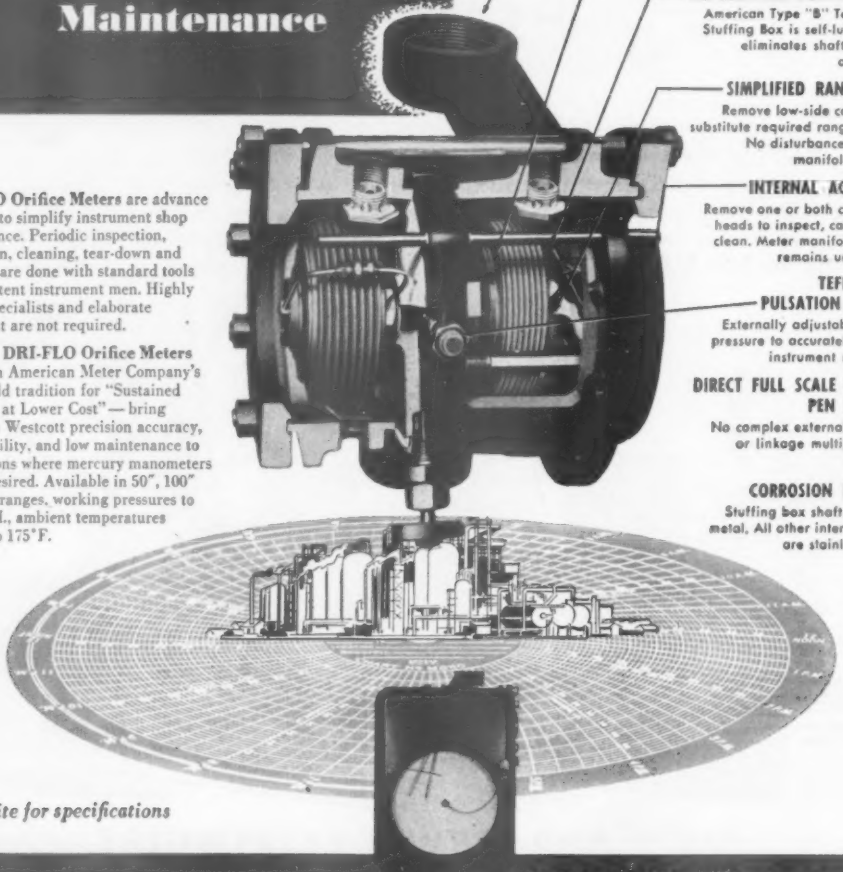
SIMPLIFIED RANGE CHANGE
Remove low-side case cover, substitute required range spring. No disturbance of meter manifold piping.

INTERNAL ACCESSIBILITY
Remove one or both case cover heads to inspect, calibrate or clean. Meter manifold piping remains untouched.

TEFLON-SEALED PULSATION DAMPENER
Externally adjustable under pressure to accurately control instrument response.

DIRECT FULL SCALE RECORDING PEN MOVEMENT
No complex external gearing or linkage multiplication.

MAXIMUM CORROSION RESISTANCE
Stuffing box shaft is Monel metal. All other internal parts are stainless steel.



Write for specifications

AMERICAN METER COMPANY

GENERAL SALES OFFICE, 1513 Race Street, Philadelphia
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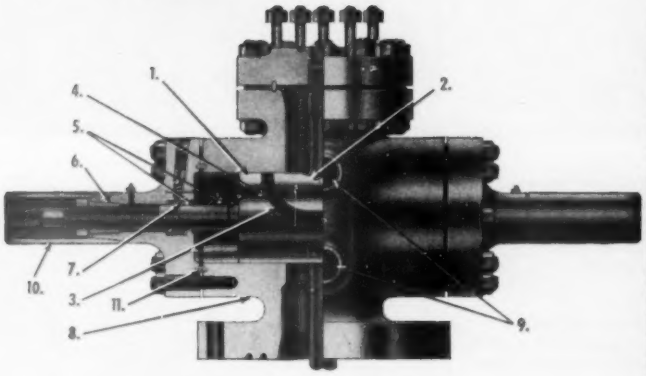
IN CANADA: Canadian Meter Company, Limited Hamilton, Ontario • Edmonton, Alberta

RECTOR ROUND RAM TUBING HEAD

Better Service and Performance through Better design . . . and construction!



● It takes all of these "Points of Superority" to give you everything you expect . . . and more . . . in service and performance from a ram type tubing head. That's why every one has been incorporated in the Rector Type CRS Round Ram Tubing Head.

They make the Type CRS the most efficient ram type tubing head you can install. You have a dependable, leak-proof seal for the life of the well. Rams operate smoothly and easily even after long standing. Placement of side outlets assures most convenient hook-up arrangement. Three methods of tubing suspension and stripper bowl interchangeable on the body assure flexibility to meet changing well conditions.

When installing a ram type tubing head, specify the Rector Type CRS Round Ram Tubing Head to get better service and performance. Ask your Rector Representative or authorized supply store.

POINTS OF SUPERIORITY

1. ROUND RAMS
Mud cannot accumulate on top to obstruct movement. Greater strength for suspending longer strings.

2. TWO-PIECE RAMS
Upper front segment is secured to main body by shoulder screw. One-piece, pre-formed oil resistant packing is inserted between the two segments. Packing is not under pressure while ram is being moved.

3. PRESSURE SEALING ELEMENT
When rams are closed upper segments and packing make first contact, forcing packing into pressure-tight seal with ram cylinder and around tubing.

4. SIMPLIFIED PACKING ARRANGEMENT
permits equalized pressure on under side and back of rams without ports or by-passes.

5. VALVE SEAT
in end flange and valve face on ram screw, seat when rams are drawn back; prevents well fluids from fouling ram screw.

6. THREADED BRONZE BUSHING
for ram screw eliminates steel-to-steel thread contact . . . assures easy movement of rams.

7. PLASTIC PACKING
around ram screws, between "V" retainers, assures pressure-tight seal.

8. STRONGER BODIES
with less weight made possible by round rams.

9. SIDE OUTLETS
threaded or flanged, provided above or below rams or one above and one below.

10. RAM SCREW PROTECTOR
can be used when rams are opened or closed.

11. RAM BONNET
sealed to body with API ring gasket.

RECTOR WELL EQUIPMENT COMPANY INC

★ MAKING THE OIL INDUSTRY SAFER ★

1100 NORTH COMMERCE ST. FORT WORTH, TEXAS
Houston Plant: 2315 Commerce St.
REPRESENTATIVES IN ALL ACTIVE FIELDS

RECTORHEAD RECTOR ROUND RAM CEMENTING METHOD RECTORSEAL

Here are your ARMSTRONG TRAP REPRESENTATIVES who offer you:

NEARNESS —you don't have to look far or wait long for an Armstrong Man. There are 39 Factory Representative organizations and 135 stocking jobbers in the United States, Canada and Mexico. Armstrong traps and trap service are near wherever you may be.

SERVICE —what size trap for this job?—how to hook it up?—cold machines?—mysterious difficulties? Your Armstrong trap man will know or find the answer for you. He is factory-trained and, more importantly, he has lots of experience to help you.

RELIABILITY —Armstrong Representatives are "solid citizens," established in their communities—men who will perpetuate their organizations assuring you continuity of experience and service.

TRAPS —no delay when you need traps—local stocks are adequate for most requirements.

PARTS —most Armstrong Representatives have complete stocks of trap parts on which you can draw.

OVERHAULS —many Armstrong Representatives offer complete trap repair and "factory overhaul" service.

When you specify Armstrong traps, you'll get no "orphans." The parental interest of the sales and service organization goes with them.

SEND FOR YOUR FREE COPY OF THE 44-PAGE ARMSTRONG STEAM TRAP BOOK

ARMSTRONG MACHINE WORKS
868 Maple Street, Three Rivers, Michigan

ARMSTRONG STEAM TRAP

ARMSTRONG

1.

1. Armstrong Representatives at Armstrong Factory Sales Meeting, 1952.

2. Trap and parts stocks, Allen T. Shepherd Co., Armstrong Factory Representative, Richmond, Va.

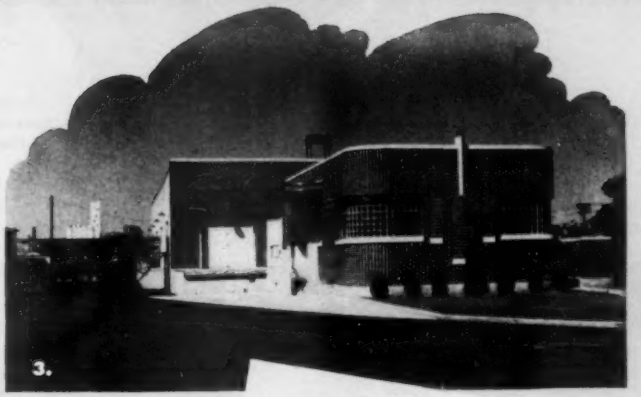
3. Office and Warehouse, Pace, Turpin & Co., Armstrong Factory Representative, Salt Lake City, Utah.

4. Trap and parts stocks, Barrett-Christie & Co., Armstrong Factory Representative, Chicago, Illinois.

5. Office interior, Wm. A. Milby Co., Armstrong Factory Representative, Baltimore, Md.

6. Headquarters of O'Brien Equipment Co., Armstrong Factory Representative, St. Louis, Mo.

● *ARMSTRONG STEAM TRAPS are backed by Armstrong Service.*



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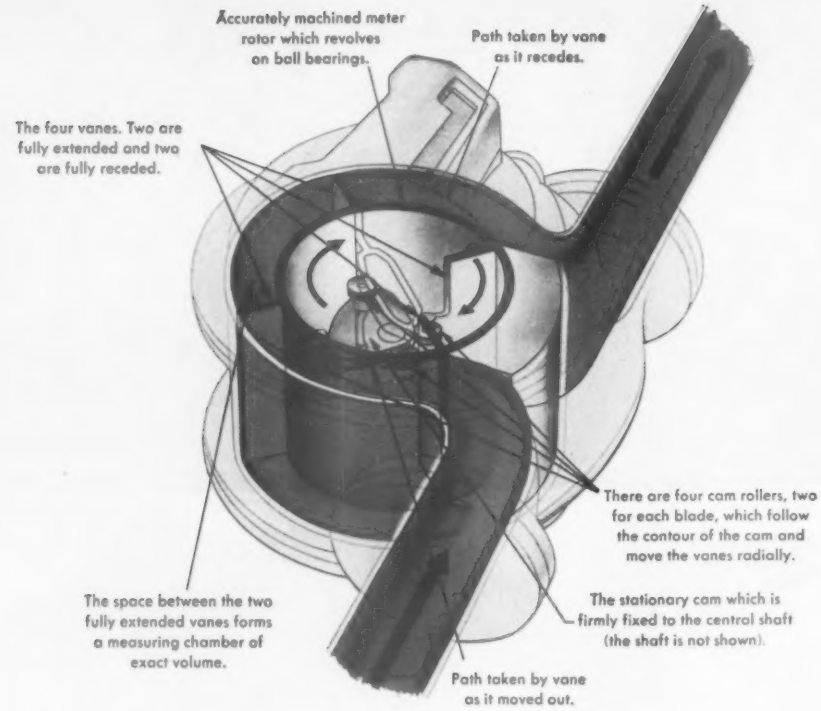
STEAM TRAPS

SATISFACTION or your money back


Accurately machined meter rotor which revolves on ball bearings.
Path taken by vane as it recedes.
The four vanes. Two are fully extended and two are fully receded.
There are four cam rollers, two for each blade, which follow the contour of the cam and move the vanes radially.
The space between the two fully extended vanes forms a measuring chamber of exact volume.
The stationary cam which is firmly fixed to the central shaft (the shaft is not shown).
Path taken by vane as it moved out.

R-O-T-A-R-Y PLUS!

20-years ago Smith originated the SMITHway Rotary Sliding Vane Principle with its **smooth, continuous, uninterrupted** *flow. The first meter built is still in daily service. Today, thousands upon thousands of SMITHway Meters serve the Petroleum Industry with accurate records of every transaction from well to consumer.*

Naturally, you want the Rotary Principle in your meters! We've been saying and doing that for 20 years. For 20 years ago Smith *originated* the SMITHway Rotary Sliding Vane Principle.

What you want is the SMITHway Rotary Principle *plus* SMITHway *functional accessories*. With this combination you get more than a meter . . . you get an *integrated* metering system *engineered* to meet *your specific requirements*, a system that simplifies accounting, increases efficiency and reduces operating costs. Only SMITH offers you such variety *and* versatility of functional accessories. See nearest representative for the complete story or write for Bulletin 125-A.

78th ANNIVERSARY 1874 - 1952

A.O.Smith

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Keeping pace with the needs developed by Canada's expanding oil industry, we at Dominion Bridge have expanded our own plants and facilities . . . particularly in oil producing areas.

For almost any type of fabricated structural steel and platework —used in refinery or field operations, remember the name: DOMINION BRIDGE.

DOMINION BRIDGE COMPANY LIMITED

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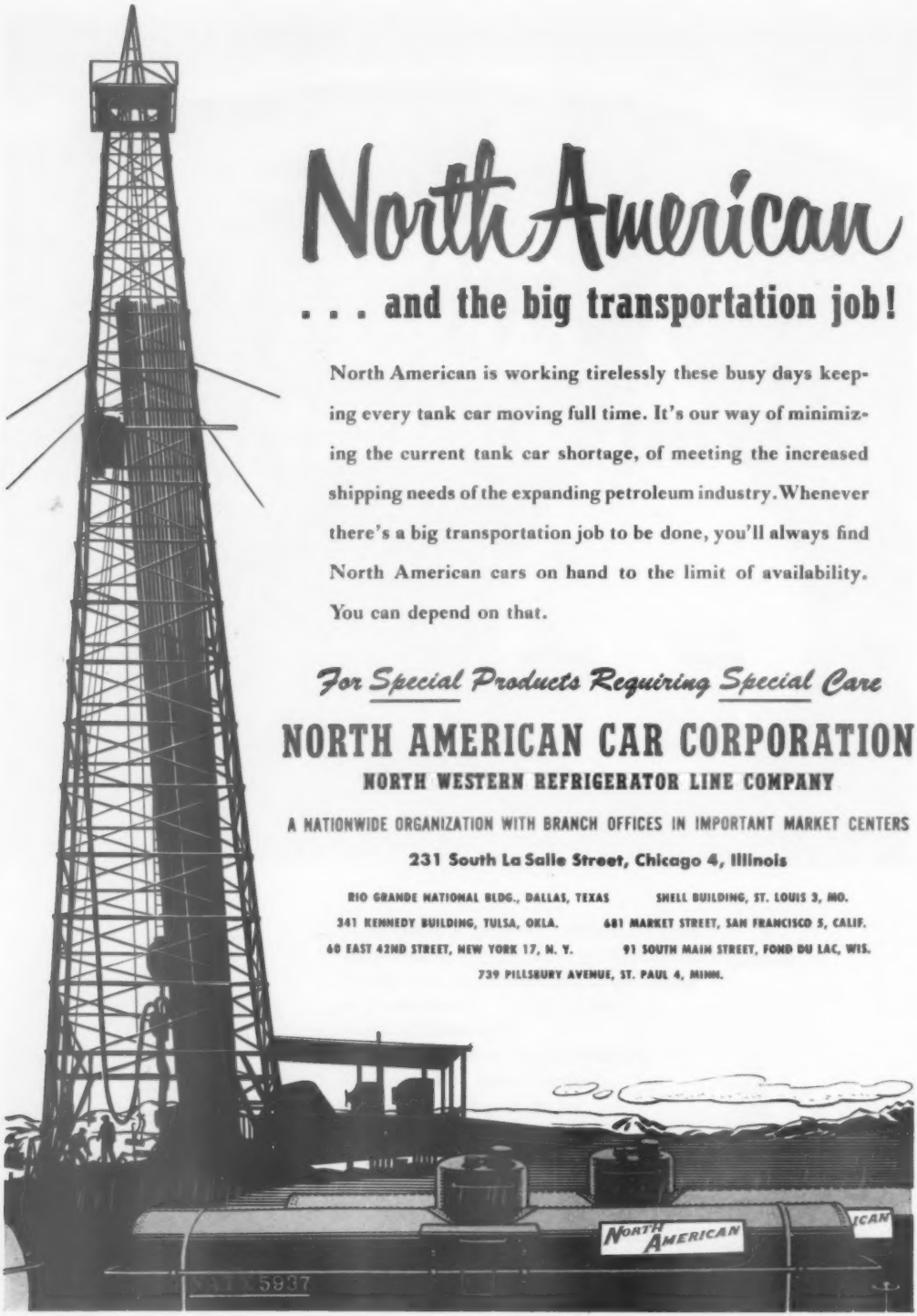

North American

. . . and the big transportation job!

North American is working tirelessly these busy days keeping every tank car moving full time. It's our way of minimizing the current tank car shortage, of meeting the increased shipping needs of the expanding petroleum industry. Whenever there's a big transportation job to be done, you'll always find North American cars on hand to the limit of availability. You can depend on that.

For Special Products Requiring Special Care

NORTH AMERICAN CAR CORPORATION

NORTH WESTERN REFRIGERATOR LINE COMPANY

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Another Carpenter First

TAMING SULPHURIC ACID with a Super Stainless Steel

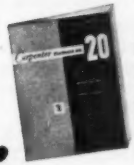
• The battery filling nozzle shown at the right was made of good 18/8 stainless steel . . . but this is the way it looked after only a two week beating from 12% sulphuric acid!

The battery manufacturer had a real headache on his hands. Hard rubber nozzles used previously resisted the acid but broke easily, sometimes as high as 10 per day. And when a nozzle broke, it tied up the production line 30 minutes or more.

Then he solved his problem by changing to nozzles made from Carpenter No. 20—the super stainless steel that handles sulphuric acid and a host of other strong corrodents. The left photo shows a Stainless No. 20 nozzle after five months' use. There is no sign of corrosion.

If you have a product or a process where corrosion is a problem, put Carpenter experience to work for you. Distributors are located in major cities from coast to coast. The Carpenter Steel Company, Alloy Tube Division, Union, N. J.

Export Dept.: The Carpenter Steel Co., Port Washington, N.Y., "CARSTEELCO"



New 16-Page Book of Technical Data

For complete information on No. 20 and the jobs it can do, write us a note on your company letterhead and ask for the new Carpenter Stainless No. 20 book.

Carpenter

STAINLESS TUBING & PIPE

Analysis → Tolerance → Finish →

- guaranteed on every shipment

For every job on the water!

RUGGED WORK . . . driving this heavy oil exploration rig in shallow, reef-strewn waters. Evinrude *outboard* power was the obvious answer. *No other type* of marine engine could do the job so efficiently, or at comparable low cost.

Count the advantages and savings: (1) Moderate initial costs. (2) No complicated — and expensive — installation work. No "extras." (3) Complete portability—motors are instantly attachable, easily transferred from hull to hull. (4) No sacrifice of equipment, cargo or crew space. (5) Simple to operate and service. (6) Safe operation in shallowest waters.

For large work boats and fast ferry service, the "Big Twin" (illustrated at left) is an exceptionally satisfactory power plant, delivering 25 B.H.P. in continuous heavy duty service. Gearshift with Neutral-Forward-Reverse gives full maneuverability, and separate Cruis-a-Day Tank provides long-range fuel supply.

Other Evinrude models 3, 7.5 and 14 horsepower. For descriptive literature write EVINRUDE MOTORS, Dept. C, 4809 N. 27th Street, Milwaukee 16, Wisconsin.

In Canada: Manufactured by Evinrude Motors, Peterborough, Ontario

EVINRUDE OUTBOARD MOTORS

ALFCO FOAMITE AIRFOAM

The Foamite Airfoam-Generating Nozzle produces Foamite Airfoam by the scientific mixing of water, air and Foamite Airfoam solution. Light in weight, the nozzle can be moved about easily when fighting a fire.

The Foamite Airfoam it produces blankets fire with a thick, stable insulation which shuts off oxygen and smothers fire quickly and easily—and it *stays* smothered! It extinguishes fire in both ordinary free-burning materials (Class A fires) and combustible materials (Class B fires). It floats on the surface of burning liquids, quickly surrounds obstructions, and clings to solids. It prevents reflash.

Foamite Airfoam Liquid operates with fresh or salt water; with hot or cold water; will not ferment or mold; is not susceptible to decomposition from bacteria; is noncorrosive; available in 3% or 6% solution.

The Foamite Airfoam-Generating Nozzle is furnished in three capacities, model 300, 600 and 1200, producing at 100 psi operating pressure, approximately 300, 600 and 1200 gallons of Foamite Airfoam respectively. Write for literature.

AMERICAN-LAFRANCE-FOAMITE Corporation
ELMIRA · NEW YORK · U.S.A.

ALFCO

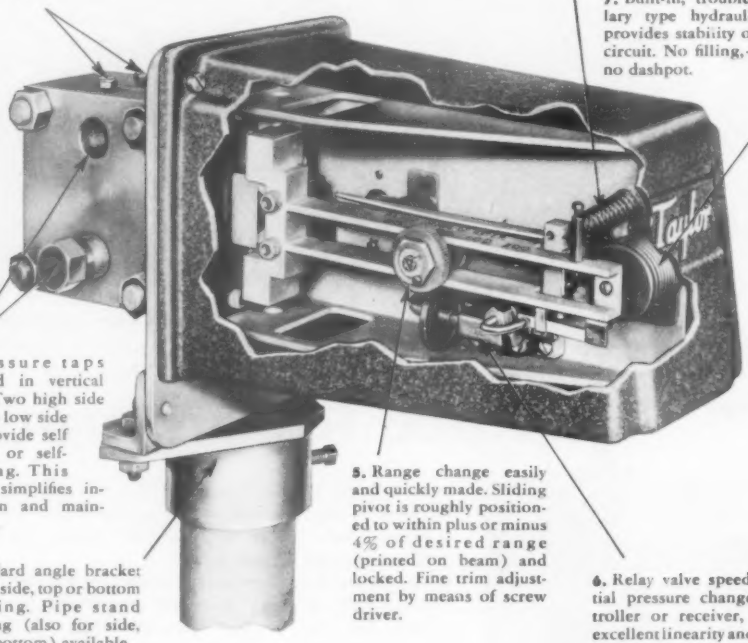
Taylor announces

1. Dry meter operates on force-balance principle. Diaphragm of Teflon coated glass cloth. Body working pressure rating 1500 psi. Available in either forged steel or type 430 stainless steel.

2. Vent screws to provide for total filling in liquid service.

8. Provision for adjustment of range suppression up to 100%.

7. Built-in, trouble-free, capillary type hydraulic damping provides stability of pneumatic circuit. No filling,—no mess—no dashpot.

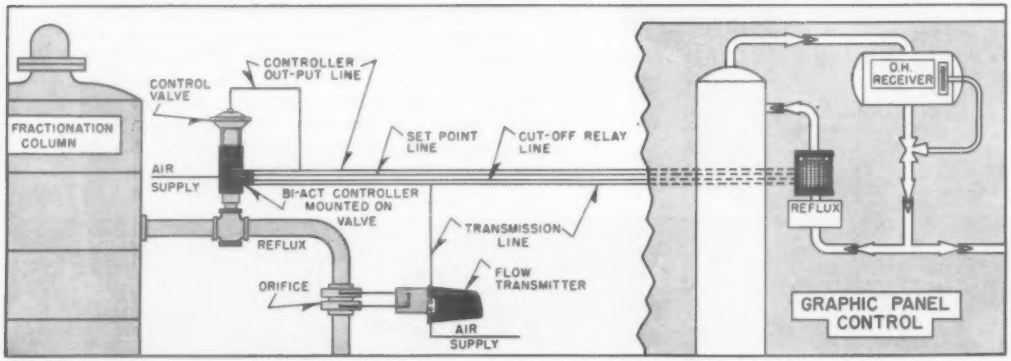


3. Pressure taps mounted in vertical plane. Two high side and two low side taps provide self venting or self-draining. This feature simplifies installation and maintenance.

4. Standard angle bracket permits side, top or bottom mounting. Pipe stand mounting (also for side, top or bottom) available.

5. Range change easily and quickly made. Sliding pivot is roughly positioned to within plus or minus 4% of desired range (printed on beam) and locked. Fine trim adjustment by means of screw driver.

6. Relay valve speeds differential pressure changes to controller or receiver, providing excellent linearity and minimum hysteresis.



SIMPLIFIED FLOW MEASUREMENT

With the NEW Taylor TRANSAIRE® Differential Pressure Transmitter

INEXPENSIVE AND SIMPLE TO INSTALL

1. Simplified piping because it can be close coupled to orifice flanges.
2. No leveling—mercuryless dry meter.
3. Side, top or bottom bracket mounting; available with 2″ pipe stand.
4. No seal pots required—negligible displacement because of force balance construction.
5. Light weight for easy handling; weighs only 23 lbs.
6. Vent screws for simple, solid filling.

ECONOMICAL—EASY TO MAINTAIN

7. Self draining or venting—no periodic manual venting or draining.
8. Mercuryless — flexible but tough Teflon coated glass fabric diaphragm.
9. Overrange protection to full body rating.
10. Purges, if required, can be installed to keep body swept clean.
11. Simple range change by sliding pivot—screw driver trim.

ACCURATE

12. Relay valve for linearity, minimum hysteresis, fast speed of response.
13. Pressure effect 0.2% / 100 psi. change.
14. Temperature effect 1.0% / 100°F. change.
15. Self draining and venting. No errors build up during operation.
16. Damped pneumatic circuit—stable air output even on vibrating pipe lines.

RUGGED AND DEPENDABLE

17. Body forged steel or type 430 Stainless Steel. Working pressure rating, 1500 psi.
18. Weather proof housing built for tough service and outdoor mounting.
19. Force balance construction—negligible motion—minimum possible wear.
20. Process sealing bellows 3-ply type 316 stainless steel.

ADAPTABLE

21. 100% suppression—continuously adjustable from 0 to 100%. Ideal for liquid level applications.
22. Ten-to-one rangeability in each of two forms: a. 20-200″ water b. 80-800″ water.

Find out more about this new flow and liquid level transmitter. Ask your Taylor Field Engineer, or write for **Bulletin 98226.** Taylor Instrument Companies, Rochester, N. Y., and Toronto, Canada. *Instruments for indicating, recording and controlling temperature, pressure, flow, liquid level, speed, density, load and humidity.*

Taylor Instruments
MEAN
ACCURACY FIRST
IN HOME AND INDUSTRY

LIMITORQUE

puts Valve Operation in the hands of Key Workers

Refinery and pipe line valves of all types can be opened and closed quickly and safely with LimiTorque. Conveniently located push button stations are the control centers from which even remotely located valves may be operated by highly responsible employees. It is unnecessary to entrust important valve operations and valuable equipment to men chosen for brawn alone.

Operators know exact position of each valve at all times by indicating lights.

LimiTorque functions properly under all climatic conditions. Actuation may be by electricity, air, natural gas, or any other available power source.

OUR 60TH ANNIVERSARY

Philadelphia Gear Works, INC.

ERIE AVE. AND G ST., PHILADELPHIA 34, PA.

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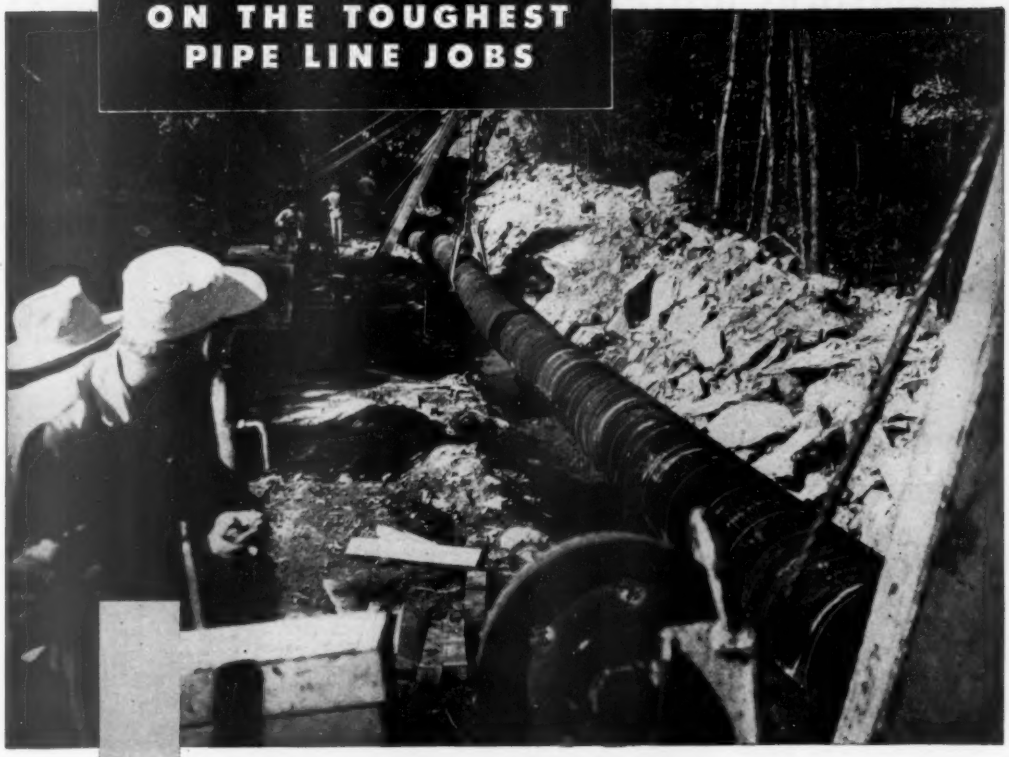
Industrial Gears and Speed Reducers
LimiTorque Valve Controls

ON THE TOUGHEST PIPE LINE JOBS



Claymont Welded Steel Pipe Fits Up Faster—Lowers In Easier

Claymont pipe is made from high-tensile steel plates produced entirely in our own plants and quality-controlled through every phase of fabrication starting with the open hearth. Every length is hydraulically expanded for accurate size and perfect roundness...precision bevelled at the ends for time-saving, labor-saving ease of handling in the field.

Available in lengths of 40 feet and in overall diameters from 24 inches through 36 inches. Write to Wickwire Spencer Steel Division, Claymont Plant, Claymont, Delaware or our nearest sales office.

FLANGED AND DISHED HEADS...CARBON, ALLOY AND STAINLESS-CLAD STEEL PLATES
LARGE DIAMETER STEEL PIPE

THE COLORADO FUEL AND IRON CORPORATION – Denver, Colorado
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CLAYMONT
WELDED STEEL PIPE
PRODUCT OF WICKWIRE SPENCER STEEL DIVISION
THE COLORADO FUEL AND IRON CORPORATION

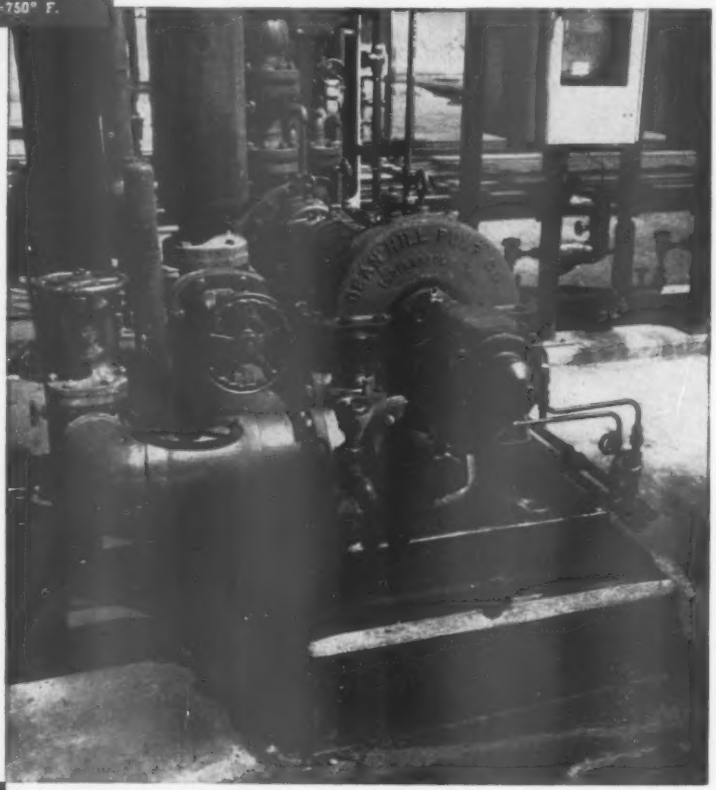
Designed with the operator in mind!

HORSEPOWER UP TO 1000
PRESSURES UP TO 875 LBS.-750° F.

No streamline housings.
No needless cover-ups.
Nothing fancy or frilly about these power-making huskies. Dean Hill Steam Turbines are designed and built for nothing but long service and easy, economical operation. Their heavy, rugged construction is simple and uncluttered for quick, easy maintenance. All pressure parts are outside and visible to operator.

DEAN HILL STEAM TURBINES

.....are single stage, double impact type for low steam consumption. Specifically designed for operation at medium steam pressures and temperatures, DH Turbines have all the advantages available under these conditions, including excellent water rates. Write us for further information and complete specifications.



One of eighty-four Dean Hill Steam Turbines recently installed in a large, eastern Refinery

DEAN DH HILL PUMP COMPANY

Pump and Turbine Engineers Since 1895

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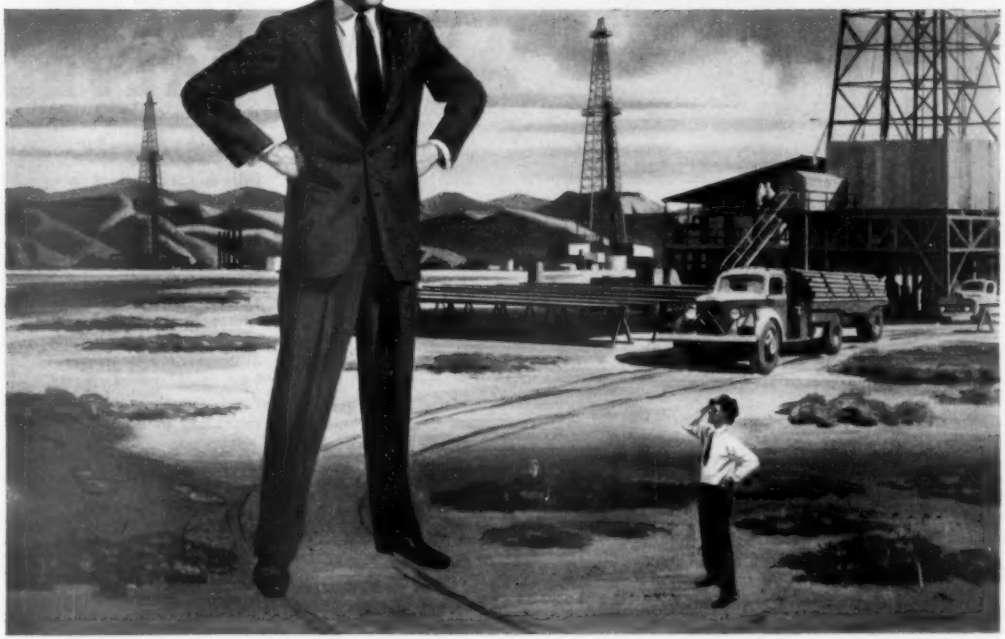
How big is a good customer ?



Indispensable links in the far-flung chain of oil activity, today's Supply Stores and Service Companies present tremendous advantages to drillers and producers throughout the industry. Maintenance of large inventories of vital equipment, prompt deliveries even to remote locations, and dependable engineering and technical advice are only part of their manifold services in all areas where oil is found. And dominating the scene of oil progress is the Customer whose equipment needs create these services. Without *him*, they wouldn't exist. Whether he's an old friend of long standing or a newcomer in the field . . . whether his order amounts to five dollars or five thousand or more . . . the Customer remains the motivating power behind the suppliers who serve him.

P.E.S.A.

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PARTNERS IN PETROLEUM PROGRESS

Petroleum Equipment Suppliers Assn.

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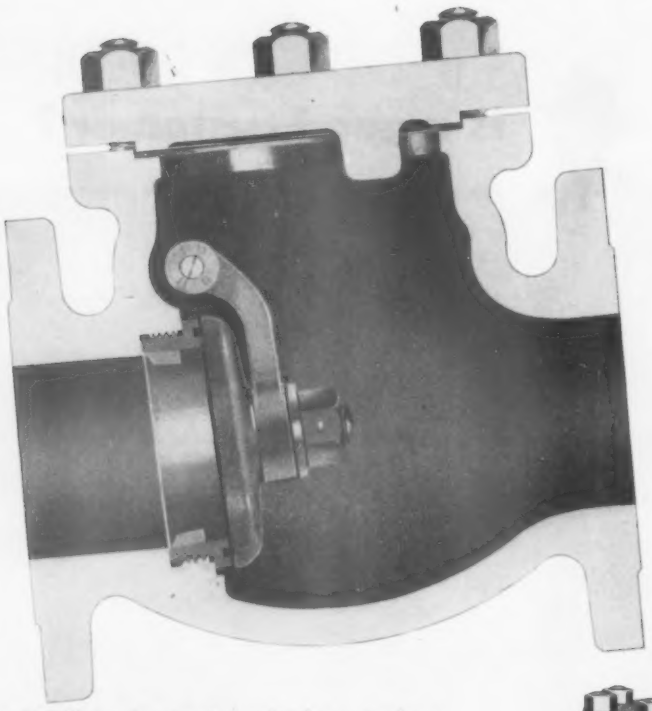

Rubber Insert CHECK VALVES

Now available from warehouse stocks . . . Pacific's newest line of Swing Check Valves, fitted with a special Seat Ring with a bonded rubber insert providing a resiliant seating surface. This feature offers several important advantages: 1) tighter closures; 2) reduces the possibility of damaging seating faces; 3) quieter operation; 4) greater erosion resistance; and 5) longer service life. Whatever your problem or application, Pacific urges your serious consideration of these Valves.

Positive shut-offs can be expected under the most adverse conditions due to the rubber's tendency to mold itself against the seating surface forming a tight seal.

Operational impacts which tend to damage conventional seating faces are minimized because the resiliant rubber dampens the impact of closing.

Rubber Insert Check Valves offer quieter, smoother operation because the rubber has a cushioning effect and eliminates the hard metalic sound of metal meeting metal.

The damaging erosion effect of handling sandy or gritty substances is greatly reduced due to the inherent resiliancy of the rubber.

Under certain operating conditions such as those mentioned above or where corrosive conditions exist, vastly improved service life can be expected.

Pacific's Rubber Insert Check Valves are similar in construction and materials to Pacific's regular line of Cast Steel Swing Check Valves. The Body thicknesses, face to face dimension of the line flanges, and the flange dimensions all conform to applicable A.S.A. and A.P.I. specifications. All sizes offer straight thru, in-line ports; full opening discs that will not stick in the open position. Body and Bonnet are heavily patterned castings of A.S.T.M., A-216 Grade W.C.B. Carbon Steel. Trim material regularly furnished is 12% Chromium Stainless Steel. Gasketed, Male-Female Bonnet Cap Connection bolted with special high tension steel bolting.

This line of Valves is currently available in the 150 Lb. Series, sizes 1½" to 16" inclusive and in the 300 Lb. Series, sizes 2" to 12" inclusive.

When ordering, specify Figure Number 180-1R or 380-1R respectively.

Write or phone your nearest Pacific Valves, Inc., representative for further information and prices.

PACIFIC VALVES, INC.

Manufacturers of Pacific Cast, Forged and Stainless Steel Valves

3201 Walnut Avenue, Long Beach 7, California

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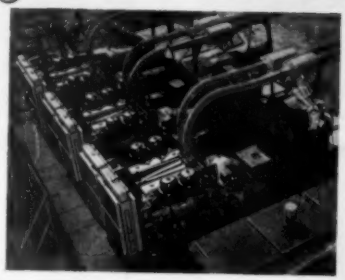
SALES OFFICES IN ALL PRINCIPAL CITIES!

GM Diesel
Case History No. 5211-12

USER: Al Buchanan Drilling Company, San Antonio, Texas. Rig No. 9.

INSTALLATION: Three GM Diesel "Twin 6" torque-converter units, powering a Clark-Ideco PR-1000 rig. Replaced other GM Diesels that had given four years' continuous trouble-free service. Bought new GM Diesels to get dual-fuel torque-converter units.

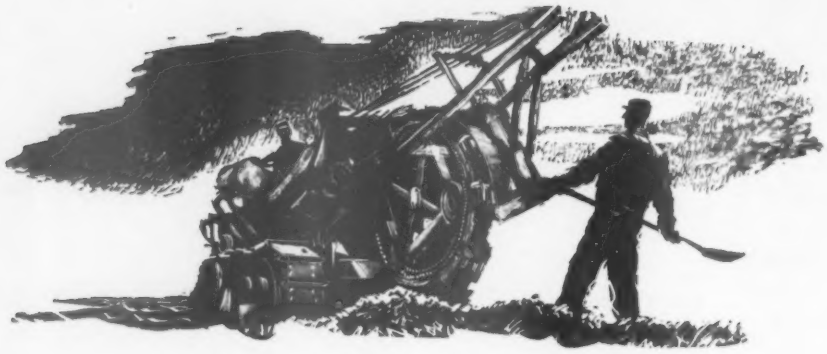
PERFORMANCE: Since July, 1950, engines have drilled more than 85,000 feet of hole (one well 12,000 feet deep). Maintenance costs negligible and owners report, "we are happy to recommend GM Diesels."



This Diesel Gives Drillers More Power

with fewer units . . . less weight . . . less space

GM
GENERAL MOTORS
DIESEL POWER



Canada's **OIL** Bank

Ask the Royal about Canada's Oil. This bank has been operating in the Canadian oil fields since the earliest days. It has taken a leading role in providing assistance and encouragement to those responsible for the expansion of the industry. Its branches completely blanket the areas of active oil and gas development. Many of them are in the heart of the major producing districts. At Calgary the bank has a special department geared to provide information and render active assistance to oil and gas men.

Inquiries are invited.

★ ★ ★

United States Banks are invited to use the unequalled facilities of The Royal Bank of Canada in servicing the accounts of United States clients interested in Canadian oil development.

Address your inquiries to J. C. Mayne, Supervisor, Calgary, Alberta, or to Head Office, Montreal.

Branches in Calgary, Edmonton, Leduc, Devon, Redwater, Turner Valley and many other areas of active development. 57 branches in Alberta alone.

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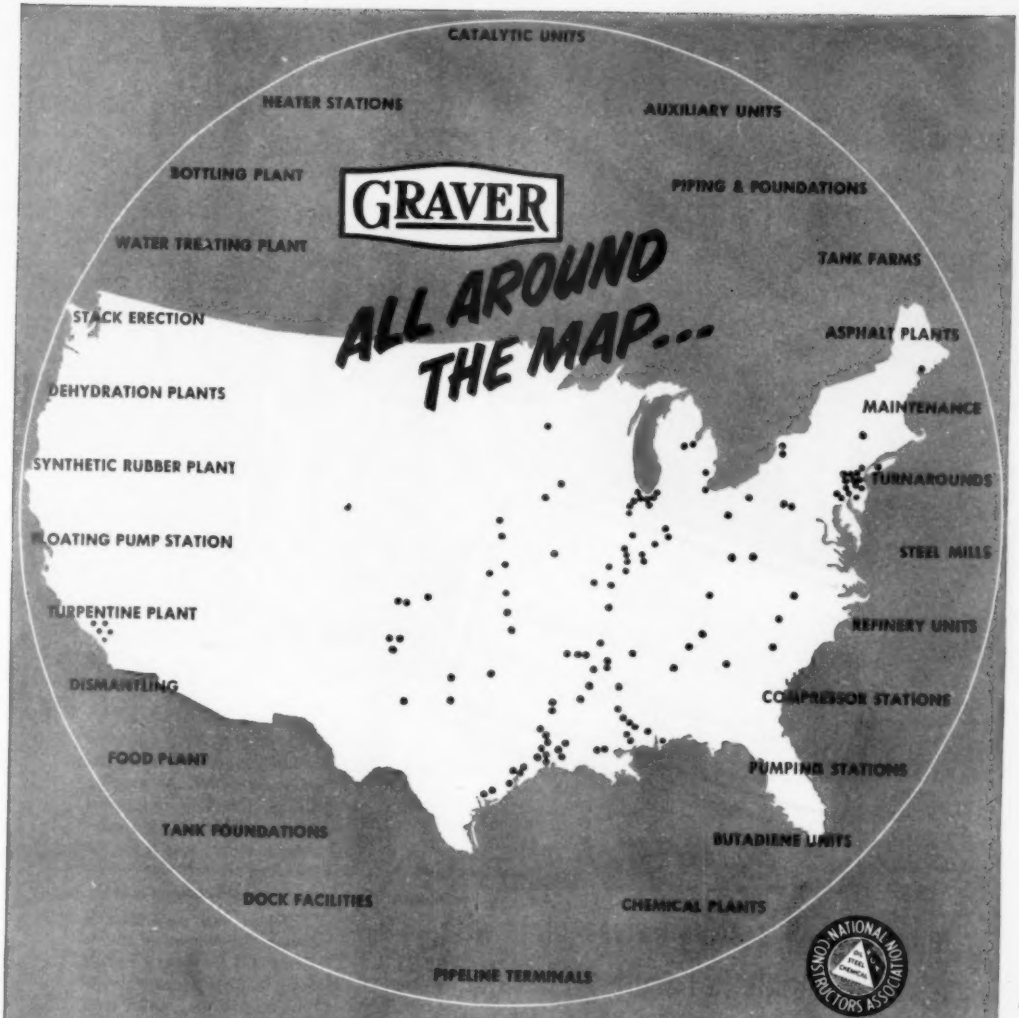
ASSETS EXCEED $2,500,000,000



GRAVER INDUSTRIAL CONSTRUCTION OF ALL TYPES

All over the country—and abroad—Graver Construction Co. has built a great variety of industrial plants and has achieved a high record for jobs accomplished on time and as specified.

Graver Construction Co. serves all branches of the chemical, petrochemical and petroleum fields, including transcontinental pipelines for crude, product, and natural gas.

This record of service, over more than a decade, denotes the experience, versatility and dependability inherent in the Graver name.

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A DIVISION OF
GRAVER TANK & MFG. CO., INC.
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GRAVER

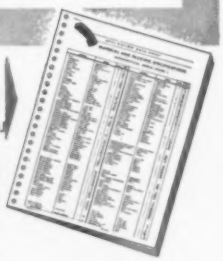
An Invitation to the Chemical Industry from Chiksan Engineering

CHIKSAN makes a range of ball bearing swivel joints with packing materials to handle practically all types of salts, acids, alcohols, glycols, aldehydes, alkaline solutions, animal oils, aromatics, chlorine derivatives, volatile gases and soaps.

Whether it's propane, butyl alcohol, vegetable oils or sulphuric acid, CHIKSAN loading racks with ball bearing swivel joints can be depended upon to handle these hard to handle chemical products with ease, economy and complete safety.

Chiksan has material and packing specification sheets listing 317 chemical products with recommendations for types of joints, metal and packing material to be used.

Write for Chiksan Application Data Sheet and Catalog 51-C Dept. No. 11-OGJ

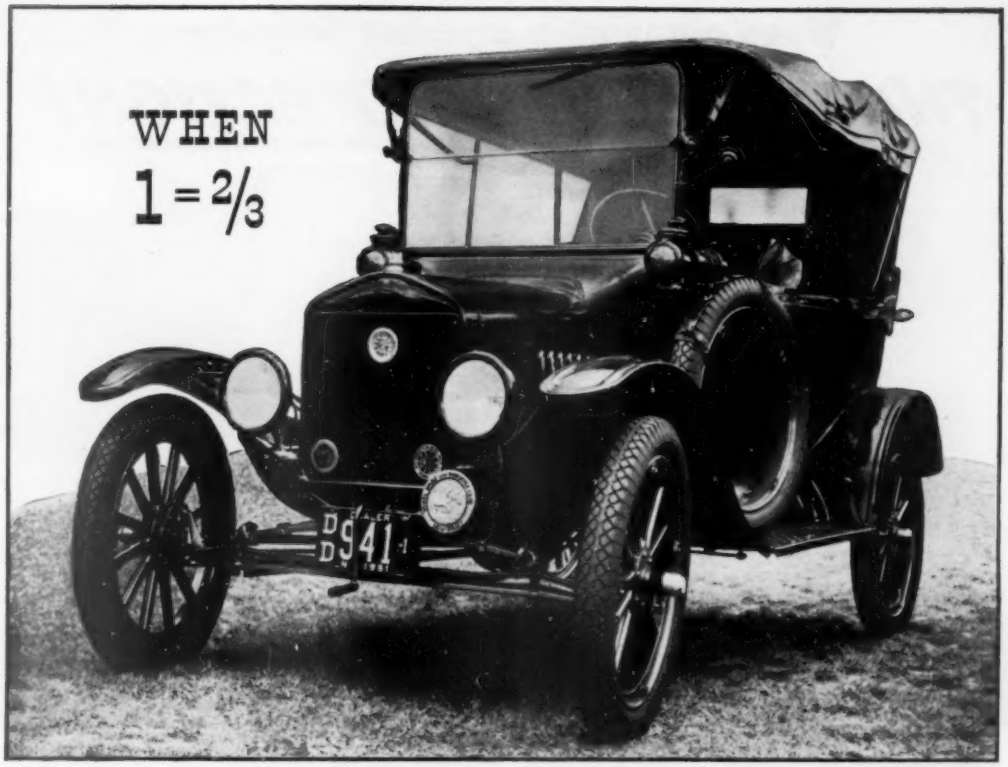


The Flow of Enterprise Relies on **CHIKSAN** *Ball-Bearing Swivel Joints*

Representatives in Principal Cities

CHIKSAN COMPANY • BREA, CALIFORNIA • Chicago 28, Illinois • Newark 2, New Jersey

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Chiksan Export Company (Subsidiary), Brea, California • Newark 2, N. J.



Those were the good old days?

Horsepower without horses! Ever since this dream became a reality, the progress of the automotive industry has been sometimes spectacular . . . always steady.

Long and heated were the arguments over the respective merits of chain vs. gear drives, poppet vs. sleeve valves, two-wheel vs. four-wheel brakes, and the like.

HOW DIFFERENT TODAY!

We take good performance pretty much for granted, nowadays. Engines squeeze more power from each gallon of gasoline. And thanks to the petroleum industry's constant search for better products, 2 gallons of today's gasoline do the work of 3 gallons of "1925-model" gasoline!

Such progress is typical of the achievements of the petroleum industry . . . working in cooperation with the American Petroleum Institute, now meeting in Chicago. Skelly Oil Company pledges continued support of the American Petroleum Institute in bringing good *new* days to the American motorist!

SKELLY

SKELLY OIL COMPANY

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When planning a pipe-line project—

THINK ABOUT PROTECTION!

Bitumastic Enamel being machine-applied

● When planning a new pipe line, it's wise to include Bitumastic Enamel in your original plans. These coal-tar enamels have established remarkable records for preventing corrosion . . . they have *proved* what they can do. Many oil and gas pipe lines—laid in the nineteen twenties — are still giving good service today, thanks to these durable enamels.

There are many reasons why Bitumastic Enamels are the best barrier against corrosion. Here's an important one: through the years, Bitumastic Enamels keep moisture away from pipe-line surfaces, and that prevents corrosion. *Ordinary* protective coatings just can't keep out moisture year after year.

Specify Bitumastic Enamels for *your* next pipe-line project. It's the sure way to guard against corrosion. For complete details and estimates, get in touch with one of our representatives.

Bitumastic Enamels now available from Koppers new Fontana, California, Plant!

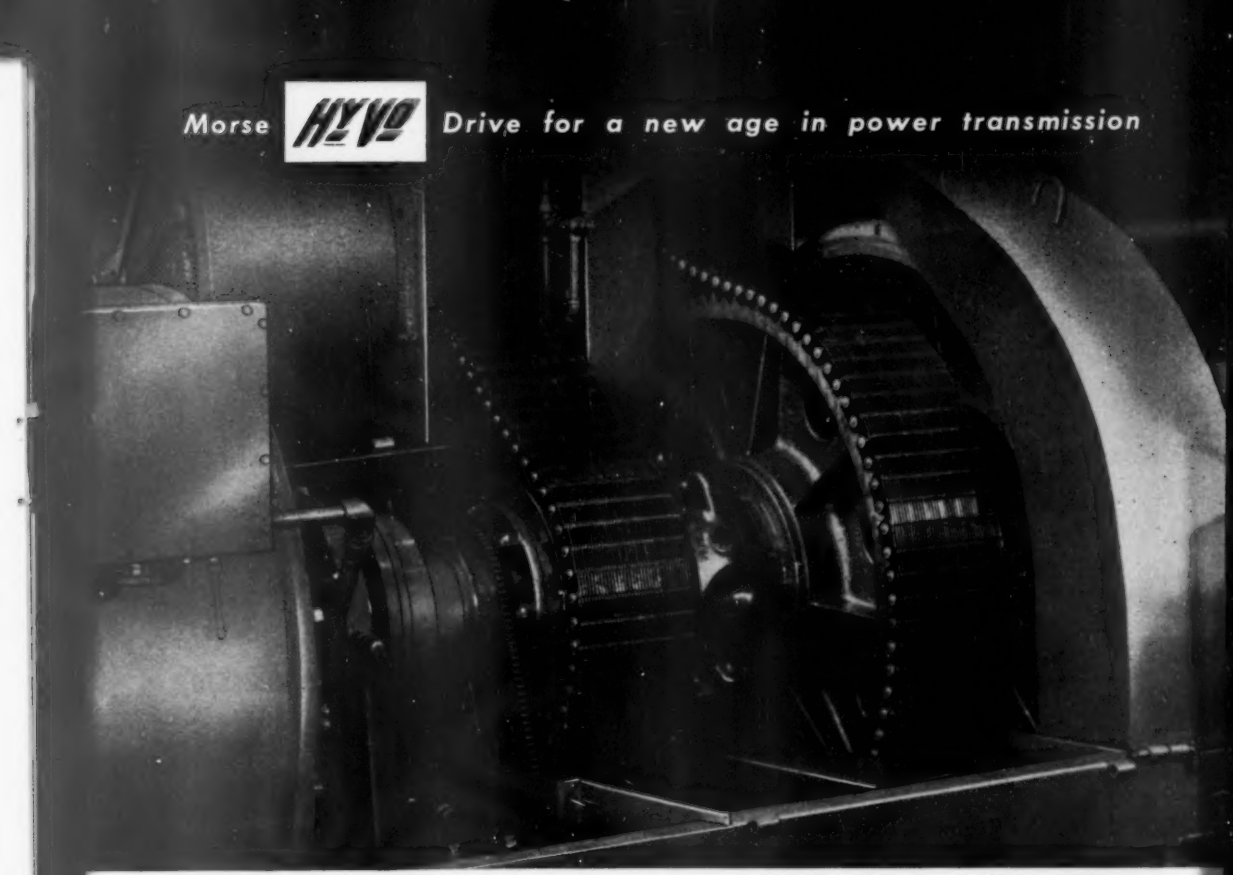
Koppers can now supply Bitumastic Enamels from its new plant at Fontana, California. This plant was built in order to give you better service in the west.

KOPPERS BITUMASTIC® ENAMELS

KOPPERS COMPANY, INC., Tar Products Division, Dept. 1103-T, Pittsburgh 19, Pa.

DISTRICT OFFICES: BOSTON, CHICAGO, LOS ANGELES, NEW YORK, PITTSBURGH, AND WOODWARD, ALA.

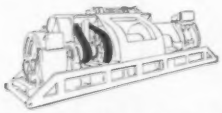
Morse HY-VO Drive for a new age in power transmission



Now, more horsepower, greater speed plus portability

possible for first time in oil field drawworks

Once, oil field drawworks powerful enough to drill 20,000-foot holes had the portability of small apartment buildings; had to be knocked down, trucked piecemeal from hole to hole site, reassembled. Very costly.



Now, the *portable* model shown above supplies 1500 HP at 600 RPM. And just two 2"-pitch by 12"-wide Hy-Vo Drives transmit its power. The Hy-Vo Drives operate at twice the speed with three times the load considered practical for conventional chain drives. Hy-Vo made this revolutionary, cost-slashing oil field development possible—and portable.

What Hy-Vo can do for you

A Morse Hy-Vo Drive will transmit more horsepower at higher speeds and lower cost than any other drive ever known. It opens the way to transmitting more horsepower from smaller, less expensive high-speed engines—without costly accessories.

Remarkable as it is, Hy-Vo is still only one of a complete line of power transmission products that has made the name Morse synonymous with exceptional engineering, exceptional quality, exceptional performance.

Write today for Hy-Vo Catalog C 72-51—or for information on Morse Silent Chain or Roller Chain Drives, Morse Flexible Couplings, Morse Drive Shafts, or Morse Clutches. (Hy-Vo orders must carry priority rating at present time.)

MORSE
MECHANICAL POWER TRANSMISSION PRODUCTS
PRODUCTS OF BW BORG WARNER

More than ever, M=PT—Morse means Power Transmission.

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ATTAPULGUS *Fullers Earth*
POROCEL *Activated Bauxites*

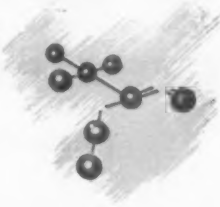
...two reliable names along the path of petroleum processing

WHAT DO YOU WANT TO PURIFY?

There's an Attapulgus or Porocel adsorbent to fit your process technique for removing odors, colors, tastes, moisture, acids, sulfur, fluorides and unsaturates from process liquids or gases. Materials treated in principal applications are: motor oils and other lubricating, specialty, and technical oils; petrolatums and waxes; aviation and motor gasoline stocks; kerosene; diesel and heating oils.

DO YOU HAVE CATALYST OR CATALYST CARRIER NEEDS?

Attapulgus or Porocel sorptive minerals are recognized standards in desulfurization, reforming and isomerization systems—catalytic removal of unsaturates—conversion of sulfides to elemental sulfur—fluid catalyst applications—as catalyst carrier in copper sweetening processes.



WHAT DO YOU WANT TO DRY?

We offer a wide range of reliable, thoroughly proved desiccants for drying air, hydrogen, carbon dioxide, hydrocarbon liquids and gases.

SPECIAL GRADES?

Mine and plant facilities permit prompt and economical production of grades meeting individual customer specifications. Our laboratories and technical staffs welcome the opportunity of assisting in research, development, design and operating problems. Your inquiries are invited.

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Dept. V, 210 West Washington Square, Philadelphia 5, Pa.

puts the HEAT on heat exchangers

By changing to Yarway Impulse Steam Traps, an oil refinery reports much hotter steam in their heat exchangers **—plus two other important extras:**

(1) They were able to operate the plant with 6 boilers instead of the 8 formerly required.

(2) Three men formerly required to service old-type traps can now be used for productive work.

Significant sidelight—these Yarway traps are operating under severe conditions, many outdoors with temperatures often below zero.

Plant after plant is standardizing on Yarway Impulse Steam Traps because Yarways are designed to deliver the most premium B.T.U.'s at top temperatures into your process or product. **They get equipment hotter, sooner ... and keep it hot.**

Other reasons—small size, easy installation, good for all pressures, only one moving part, low maintenance, low price.

Buy your Yarway Impulse Steam Traps from one of the 216 distributors handling this product.

ACTUAL SIZE ¼" YARWAY STEAM TRAP

YARNALL-WARING COMPANY
136 Mermaid Ave., Philadelphia 18, Pa.

FREE OFFER. Don't take our word for it. Test Yarway's advantages in your own plant, without cost or obligation. Drop us a card or letter—a trial trap will be delivered promptly.

YARWAY the steam trap
designed with more production in mind

There's a new . . . a better way to recover condensate from gas wells

It's the NEW

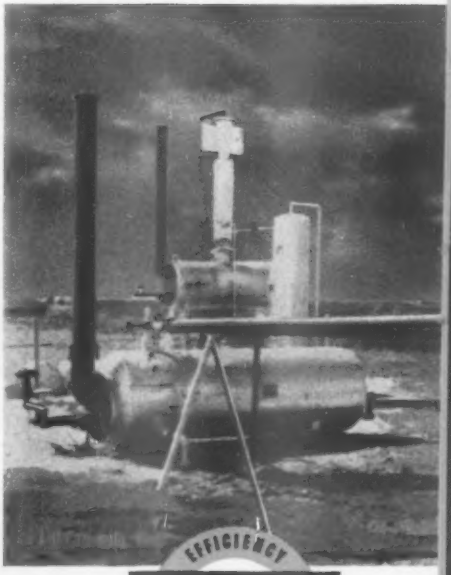
BS&B Glycol Injection System*

OF LOW TEMPERATURE SEPARATION

With STABILIZER**

There's a better way . . . and BS&B has come up with it! The old way is now the costly way . . . because it fails to give the maximum recovery now possible through the BS&B Glycol Injection System of Low Temperature Separation with Stabilizer. Glycol injection permits cooling the wellstream well below the hydrate point before expansion. By using a regenerative heat exchanger lower separator temperatures can be obtained than are possible in even the most efficient conventional low temperature separation systems. This lower temperature allows a greater liquid recovery. Should the available pressure drop fall below approximately 1000 p.s.i. required for satisfactory operation of conventional low temperature separation units, the BS&B Glycol Injection System will continue to produce pipeline specification gas even with available pressure drops of as low as 400 p.s.i.

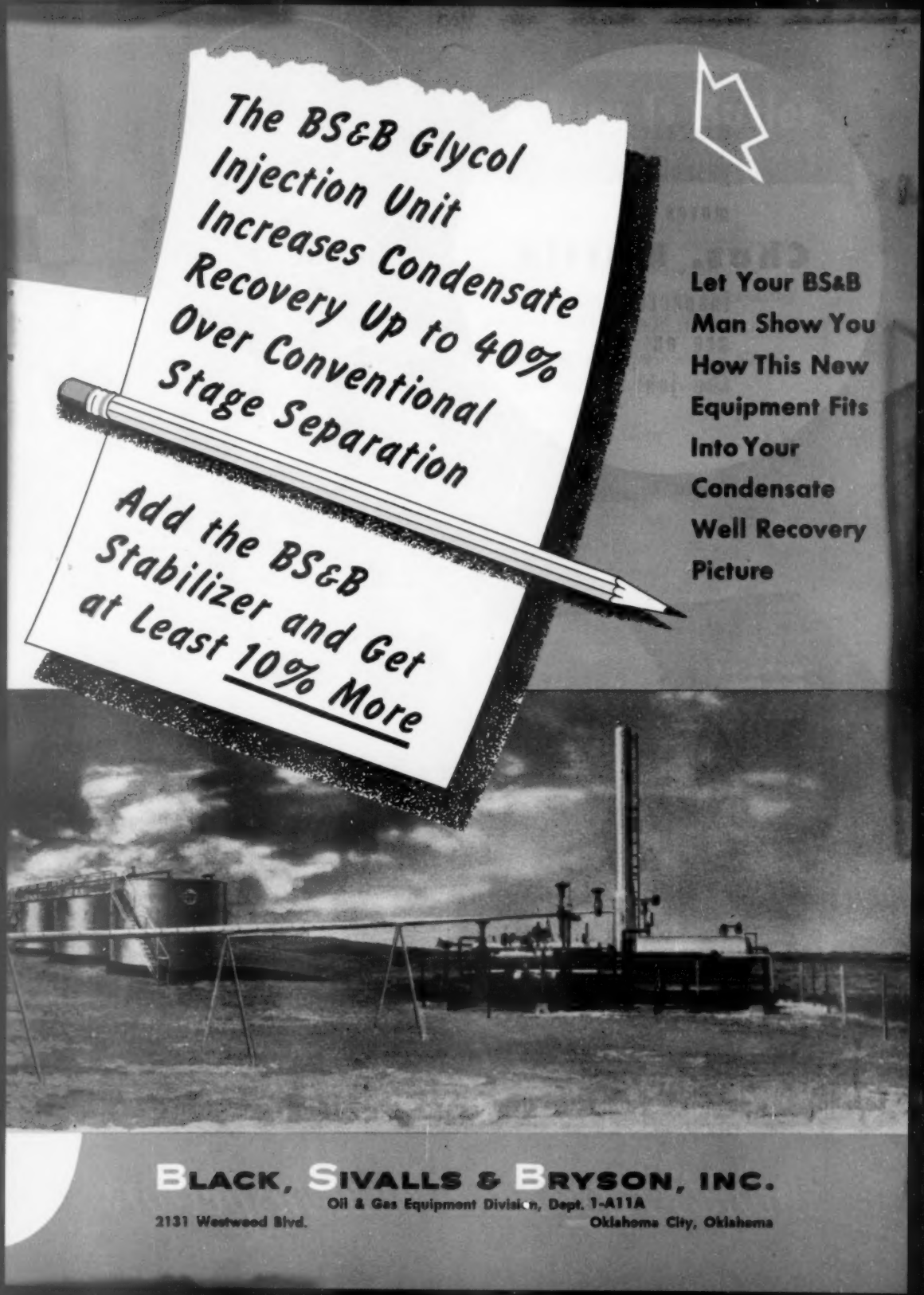
*Patented
**Patent Pending



But the recovery picture is not complete without the BS&B Stabilizer. This part of the system is today's most efficient method of getting this extra production to the stock tank—and keeping it there! The Stabilizer is a distillation column. It directs the light, wild hydrocarbons — methane, ethane, and propane—to sales. The medium and heavy hydrocarbons go to storage. The light hydrocarbons do not reach the stock tank to flash and strip the medium "easily influenced" hydrocarbons—butane and pentane—with them. You're able to keep your extra production! This much-talked-about complete recovery system can be applied to one or several wells . . . has complete versatility for off-shore or in-swamp use. Maybe you're doing it the old way . . . you'll be recovery and dollars ahead to investigate and invest in the BS&B Glycol Injection System of Low Temperature Separation *with* Stabilizer.

EFFICIENCY BS&B RELIABILITY OUR 60TH YEAR

BS&B . . . for 60 years a leader in oil & gas producing and refining equipment . . . also manufacturers of Climax Controls, Safety Devices and special fabricated pressure vessels. Ask your BS&B Man. There's one of BS&B's 35 Branches or 17 Sales Offices near you if you're in the Oil Country . . . or write . . .


The BS&B Glycol Injection Unit Increases Condensate Recovery Up to 40% Over Conventional Stage Separation
Add the BS&B Stabilizer and Get at Least 10% More
Let Your BS&B Man Show You How This New Equipment Fits Into Your Condensate Well Recovery Picture
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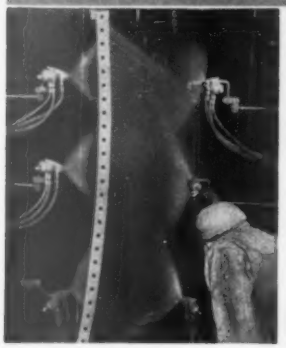
Your Best Long-Term Buy Is Butler

BOLTED STEEL OIL TANKS • WALKWAYS AND STAIRWAYS



Each tank gets better, more uniform surface protection because of Butler electrostatic paint spray equipment. This 2-coat bond helps resist corrosion, adds longer life to the tank.

Butler Bolted Tanks . . . Walkways and Stairways . . . are your best long-term buy because the extra care and skill that Butler puts into engineering and fabrication give you extra years of service.

Each Butler tank sheet is die formed and all parts are precision made and punched for an oil-tight fit and easier erection. A.P.I. specifications on all tanks from 100 to 10,000 barrel capacities.

Remember that Butler is your best long-term buy. See your Butler Distributor.

You'll Always Get Dependable Service from Your Butler Distributor

Your Butler distributor will give you dependable service on Butler Bolted Steel Tanks, Walkways and Stairways, Unit Heaters and other oil field equipment.

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BUTLER MANUFACTURING COMPANY

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somewhere in your building,
lurking like a cat....
fire is ready to pounce.
In flammable liquids,
electrical equipment, record
vaults. Your surest protection
is a Kidde Fully Automatic
CO_2 Fire Extinguishing System.

Kidde

...quick as a mouse, check the "Yellow Pages" for your KIDDE dealer

Walter Kidde & Company, Inc.,
1154 Main Street, Belleville 9, N. J.
Walter Kidde & Company of Canada, Ltd., Montreal, P. Q.

THE OLD DUTCHMEN SAID:
'Een spiering uitgooien om een snoek te vangen'
(THROW A SMELT TO CATCH A PIKE)
THE PRICE OF A SCHLUMBERGER
IS NEGLIGIBLE COMPARED TO THE
LOSS OF AN OIL WELL

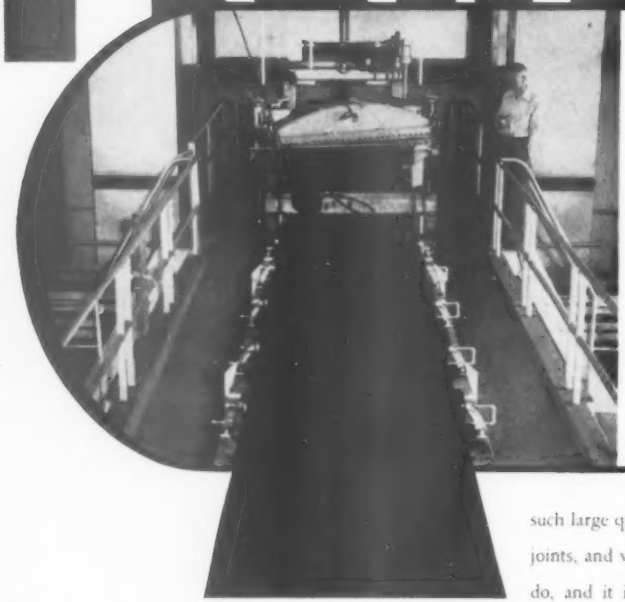
WHY OPERATORS PREFER SCHLUMBERGER

Schlumberger Well Surveying Corp. • Houston, Texas

10 Spie

Industrial rubber products especially built for LONG SERVICE

PIONEER



Pioneer Products get tough test in sewage treatment plants

This Pioneer belting is being installed for production of 220 tons of excellent fertilizer a day at the Los Angeles Hyperion Activated Sludge Plant. At storm peak, this plant handles *420 million* gallons a day.

The sweet fresh air and sparkling clean surrounding in this and other modern sewage plants give no indications of the strong chemicals, oils, and gases which are present in such large quantities. Rubber linings, gaskets, packing, belts, joints, and various types of hose have a most difficult job to do, and it is noteworthy that Pioneer Products across the country are doing it so exceptionally well in many installations.

Why? Aside from ability and experience (64 years of it), the Pioneer organization has the *willingness* to study your use of industrial rubber and to deliver either the standard or special product that will do your job *best*.

Plan now to get acquainted with Pioneer Industrial Rubber Products through your nearest Pioneer representative.

PIONEER RUBBER MILLS

Pioneering in rubber since 1888

BRANCHES: CHICAGO • CLEVELAND • DALLAS
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Distributors in other principal cities

HERE'S why this tower was insulated with FOAMGLAS

At this new gasoline plant, FOAMGLAS is used to insulate fractionating towers, heat exchangers, valves, fittings and piping and finished with an aluminum covering.

Even without a protective coating, this remarkable insulation will not transmit vapor. That's why it is the ideal material for these exposed locations where moisture is a problem.

FOAMGLAS comes in solid blocks that can be cut with a saw or simply scored and broken. As a result, it lays up fast with a minimum of labor.

Beveled and curved special shapes are available for all types of process equipment, as well as plain or factory-wrapped pipe insulation. And you can get factory-fabricated sections for all types of valves and fittings.

Send the coupon for a free sample of FOAMGLAS and our latest booklet.

Fractionating Tower at Magnolia Petroleum Company's Chitwood, Oklahoma gasoline plant.

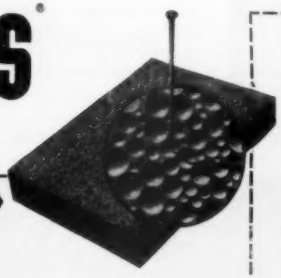
PITTSBURGH CORNING CORPORATION · PITTSBURGH 22, PA.

PITTSBURGH PC CORNING

FOAMGLAS®

the cellular glass insulation

The *best* glass insulation is cellular glass. The *only* cellular glass insulation is FOAMGLAS. This unique material is composed of still air, sealed in minute glass cells. It is light weight, incombustible, verminproof. It has unusually high resistance to moisture, chemicals and many other elements that cause insulation to deteriorate.



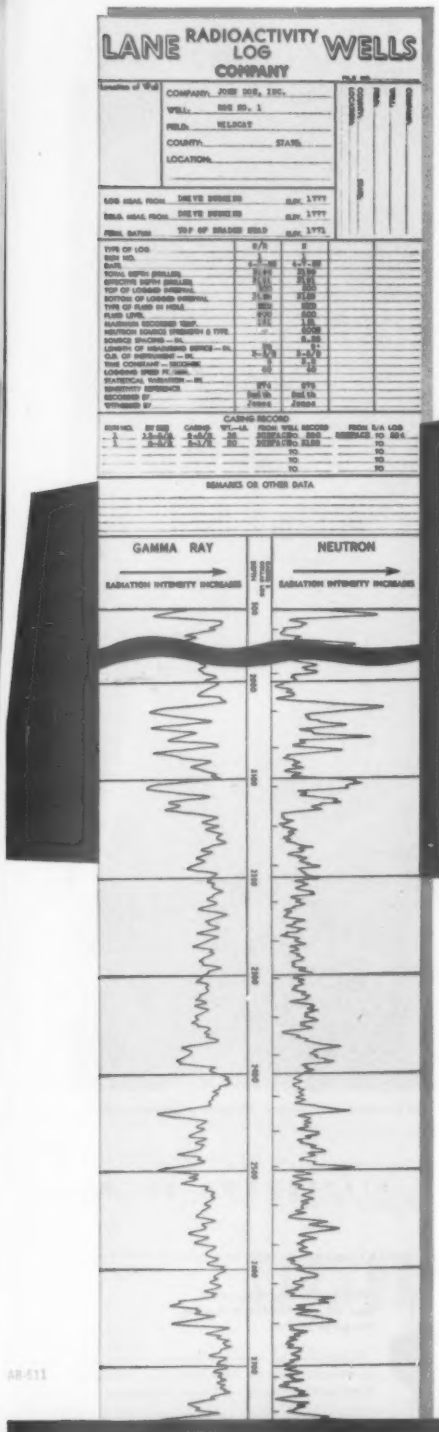
Pittsburgh Corning Corporation
Dept. DD-112, 307 Fourth Avenue
Pittsburgh 22, Pa.

Please send me, without obligation, a sample of FOAMGLAS and your FREE booklet on the use of FOAMGLAS for Piping and Process Equipment.

Name.....

Address.....

City..... State.....



A most important feature of this log isn't on it...

IT'S BEHIND IT!

Behind every Lane-Wells Radioactivity Well Log — and reflected in that log — is a great reservoir of that kind of experience which means a lot to oil operators. In running more than 48,000 logs in both cased and open hole, we have come to know, intimately, the subsurface structure of thousands of oil fields. We have learned to recognize the unusual responses due to purely local conditions, have devised, from experience, improvements in logging techniques and refinements in interpretation. All of these things mean, to the oil operator, more accurate logs, more complete down-hole information — which is why thousands of operators, from their own experience, regard a Lane-Wells Radioactivity Well Log as the best possible guide to the best possible completion.

Tomorrow's Tools Today!

AR-611

Radioactivity Well Logging by LANE WELLS

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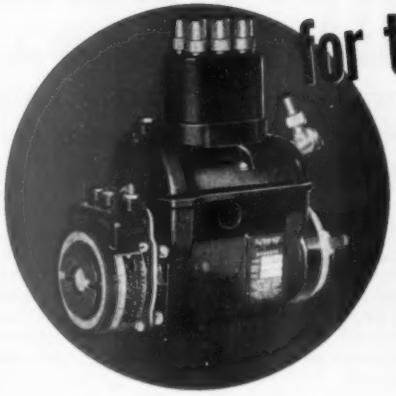
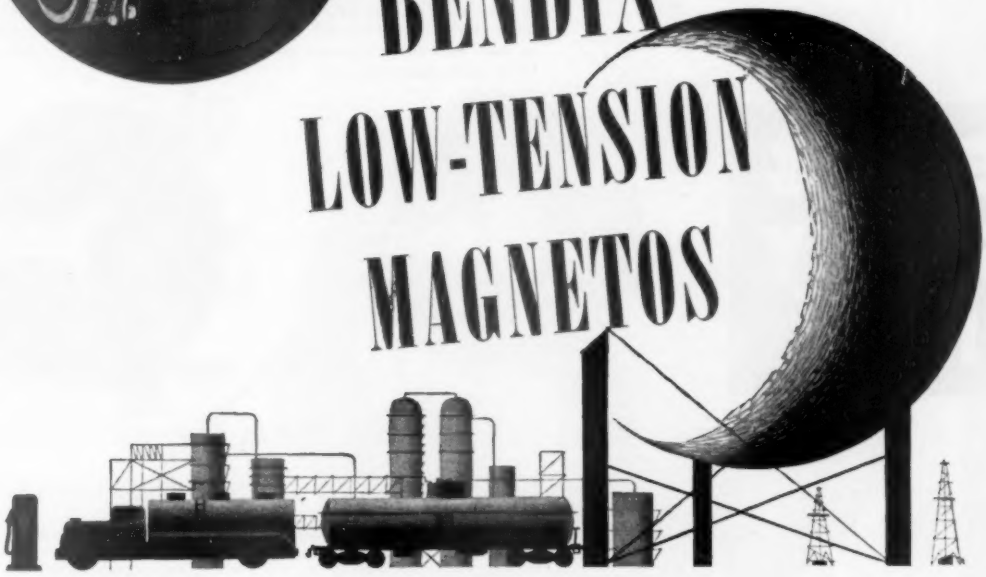
LOS ANGELES • HOUSTON • OKLAHOMA CITY • LANE-WELLS CANADIAN CO. IN CANADA • PETRO-TECH SERVICE CO. IN VENEZUELA

Designed for the Petroleum Industry—



BENDIX LOW-TENSION MAGNETOS



It's the magneto designed to eliminate fire hazard, foremost problem of the petroleum industry. The special ventilating arrangement of the Bendix Low-Tension Magneto permits air laden with explosive fumes to enter the magneto for ventilation without danger of igniting the surrounding air. Kits are also available to convert magnetos now in use to the "flame-proof" ventilation type.

In addition to this important safety feature, Bendix Low-Tension Magnetos actually reduce engine maintenance and operating costs. For example, spark plug erosion is reduced to a minimum. The distribution of low-tension voltage to the high-tension coils is through a series of breaker assemblies, thus eliminating trouble often experienced with the conventional distributor. Variable or fixed sparks can be obtained by internal adjustment.

For safety and low operating costs it will pay you to specify Bendix Low-Tension for all your magneto requirements. Complete data available on request.

- **Low Plug Erosion Rate**
- **Breaker Type Distributor**
- **Ventilation without Fire Hazard**
- **Radio Shielding Available**
- **Variable or Fixed Ignition**

Bendix

SCINTILLA MAGNETO DIVISION OF SIDNEY, NEW YORK

Bendix AVIATION CORPORATION

Export Sales: Bendix International Division, 72 Fifth Avenue, New York 11, New York

FACTORY BRANCH OFFICES:

117 E. Providencia Avenue, Burbank, California • Stephenson Building, 6560 Cass Avenue, Detroit 2, Michigan
Brouwer Building, 176 W. Wisconsin Avenue, Milwaukee, Wisconsin • 582 Market Street, San Francisco 4, California

Damocles needed a SAFETY HEAD

Remember the legend of Damocles? His tyrant ruler compelled him to sit in the royal court for one day with a naked sword suspended over his head by a single hair.

THE MORAL: There are many "naked swords" hanging over industry's head today too. Perhaps you're a fellow sufferer with Damocles. Your plant may be threatened by damage from overpressure within pressure vessels. Damocles needed a warrior's helmet to save him from his sword . . . he needed a "safety head" tailored to his requirements. Pressure vessels need BS&B Safety Heads tailored to your particular pressure specifications . . . designed to fail safe when overpressure occurs.

BS&B SAFETY HEAD

THE FINE LINE BETWEEN SAFETY AND DISASTER . . .

Your Best Protection From Overpressure Within Pressure Systems

The heart of the BS&B Safety Head is the rupture disc. When this disc ruptures at a predetermined pressure you relieve the overpressure within pressure systems that spells safety to your personnel, protection to your property and valuable equipment. Knowing that BS&B Safety Heads are on the job in your plant affords you mental peace.

Into the rupture disc is built a controlled weakness. It's designed to fail safe within plus or minus 5% of the predetermined pressure specifications. You give us the necessary operating information and BS&B will give you a safety head with an action that is fast, positive and accurate . . . regardless of whether your pressure applications are for air, gas or liquid—bland or corrosive.

First, the metal is selected for fabrication to specifications of any given lot of discs. Then discs are selected at random and tested to destruction after lot is completed. If each one tested does not break within 5% of the rated pressure the entire lot is discarded. Rupture discs are available within range of 5 lbs. to 40,000 lbs.

BS&B Safety Heads can be used for either primary or secondary relief.

Why not remove

one of "the swords of Damocles" that may plague you. Write today for complete BS&B Safety Head Catalog and details. There is no charge or obligation for a complete analysis of your pressure safety requirements.

BLACK, SIVALLS & BRYSON, INC.

Safety Head Division Dept. 2-A11

7500 East 12th Street Kansas City 26, Missouri

SAFETY BS&B HEADS OUR 50TH YEAR

LOW COST, HIGH VOLUME Air Handling!

Powerful "Buffalo" Limit Load Fans are ideal for large area ventilation, exhaust and air conditioning, doing an efficient job of air handling at low cost. "Buffalo" Limit Load Fans like this have features for extra efficiency and quiet operation, such as double backward curve blades, directional inlet vanes, specially shaped housing and dynamically balanced wheels. Another important advantage is the non-overloading feature providing positive motor protection regardless of system pressure. For complete information, write for your FREE copy of Bulletin 3737 today!

"Buffalo" LIMIT-LOAD FANS

"Buffalo" Limit-Load Fan with silent, floating base.

75 YEARS DIAMOND JUBILEE ANNIVERSARY

"Buffalo" FIRST FOR FANS

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PUBLISHERS OF "FAN ENGINEERING" HANDBOOK

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VENTILATING | PRESSURE BLOWING AIR CLEANING | COOLING AIR TEMPERING | HEATING INDUCED DRAFT | FORCED DRAFT EXHAUSTING

A Good Start

TOWARD A SUCCESSFUL CEMENT JOB

When you come across a scene like this — and there have been tens of thousands of them — you can be sure that the cementing job under way is off to a mighty good start.

Larkin Geyser Shoes and Float Collars contribute all that float equipment can to a successful cement job. The slurry speeds from the shoe in a conical sheet to remove bridges and cavings and to cut mud cake from the hole wall. The Shoe distributes cement evenly at the shoe point, providing the best chance for an even flow of cement up around the casing and reduces the possibility of channeling. Both the Geyser shoe and the Float Collar have bakelite back pressure valves that are stronger than you'll ever need, but which may be easily drilled out. Specify Larkin ". . . Through Your Supply Store."

LARKIN

. . . Through Your Supply Store

LARKIN PACKER CO., INC., ST. LOUIS, MO.

They Say—

The Climate That's Needed

"Looking ahead, I believe that the petroleum industry will continue its present rate of progress only as long as our economic system is free to reward those who possess foresight, who work hard and who are willing to take risks.

"As long as wildcatters are free to drill wells where they want to drill, as long as oil companies are free to build refineries where they want to build, as long as oil men are free to take their chances in competition—just that long will the story of oil progress towards higher standards of living be a never-ending story, to be continued next month and next year and through all the years."

Edward L. Shea, president of Ethyl Corp., addressing the Boston Conference of Distribution.

Russia's Unearned Gain

"The Democratic administration's grand-jury investigation of the international oil business has hardly begun. Yet already it promises to be a victory — even a strategic victory — for Soviet Russia in the cold war . . .

"Since the Iranian seizure from Britain, agitation for nationalization has occurred in other areas. News of the federal legal action against American oil interests resulted at once in published demands for nationalization—or confiscation—in Lebanon, where some of our pipe lines run, and even in Venezuela, which is now our largest and safest producer of foreign oil.

"Our losses anywhere would be Russia's gain.

"Furthermore, any considerable loss of overseas oil would hasten the depletion of our own reserves."

E. F. Tompkins, writing in the New York Journal American.

An Old Friend Writes

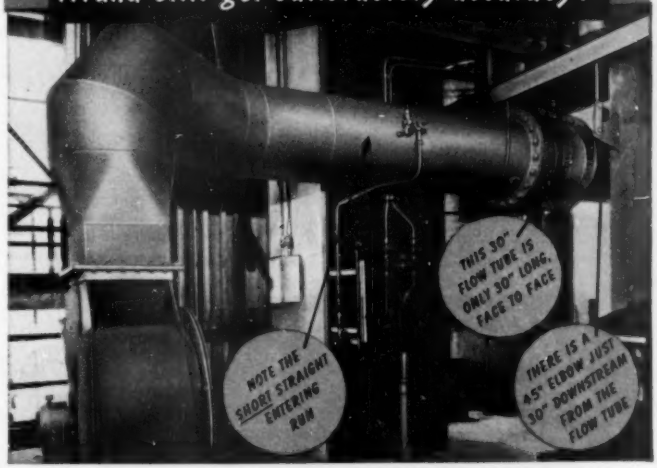
Sir:

One of the outstanding pleasant items and relations that has been extended throughout my oil-industry career has been the weekly receipt of The Oil and Gas Journal and the fact that we have always maintained personal contact with the executives of your organization.

The progress that you have annually recorded and the position that the Journal now holds is an item that must

You can put a Flow Tube in the line wherever it's *convenient*—

...and still get satisfactory accuracy!


THIS 30" FLOW TUBE IS ONLY 30" LONG, FACE TO FACE
NOTE THE SHORT STRAIGHT ENTERING RUN
THERE IS A 45° ELBOW JUST 30" DOWNSTREAM FROM THE FLOW TUBE

The Flow Tube needs only minimum straight runs entering and following the tube, and the Flow Tube itself takes up so little space that it can be installed at practically any accessible point where flow conditions are reasonably steady. This means considerable savings in space and equipment to provide straight entering runs required by conventional head meters.

The installation shown above in a catalytic cracking unit of a Southwestern oil refinery is a typical example. Here a 30" Flow Tube with a 23.9" throat (D/d = 1.26) is measuring the air used to reactivate the catalyst. It delivers a differential of 10" of water for a maximum flow of 39,000 standard cfm at 137°F. and 3.5 psig. The unrecovered head loss in this Tube at maximum flow is 1" of water. Two other tubes are also operating under similar conditions in this refinery.

All are performing satisfactorily as installed. Periodic checks all show that they are measuring within plus or minus 2% of the blower manufacturer's characteristic curve.

Flow Tubes are manufactured exclusively by Foster Engineering Co. in all pipe sizes for measuring the flow of liquids and wet or dry gases. Flow Tubes can be furnished with or without suitable secondary indicating, recording, or totalizing instruments. For further information, ask for Bulletin FT-101; and for specific recommendations, please send us necessary flow data.

FOSTER ENGINEERING Company

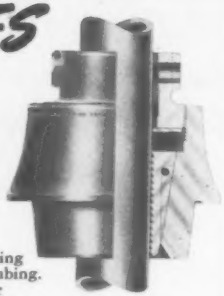
835 Lehigh Avenue • Union, N. J.

PRESSURE REGULATORS . . . RELIEF AND BACK PRESSURE VALVES . . . CUSHION CHECK VALVES
ALTITUDE VALVES . . . FAN ENGINE REGULATORS . . . PUMP GOVERNORS . . . TEMPERATURE
REGULATORS . . . FLOAT AND LEVER BALANCED VALVES . . . NON-RETURN VALVES . . . VACUUM

SEE US AT THE POWER SHOW • NEW YORK • DECEMBER 1-6 • BOOTHS 38-39

FOR SAFETY-
HERCULES
TUBING
HANGERS

The Original Overhead Packed Tubing Hanger Improved to meet present day requirements



Because of the protection assured, no well should be "put on the pump" without installing a HERCULES Tubing Hanger for suspending the tubing. It was especially designed for TUBING PROTECTION against all hazards on pumping wells. REMEMBER to include a HERCULES Tubing Hanger when you order pumping well equipment.

Write for Bulletin 101-H

SOLD THROUGH ALL SUPPLY STORES

HERCULES TOOL COMPANY
Manufacturers of Oil Field Equipment
TULSA, OKLAHOMA
General Office and Plant: 17th and Phoenix — P. O. Box 286
Telephone 3-1186
Export Representative: OIL FIELD EQUIPMENT CO., INC.
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PAGE FENCE - *Since 1883*
• AMERICA'S FIRST WIRE FENCE •

Sabotage is a danger which calls for vigilance day and night. Property line vigilance is the job for Page Chain Link Fence, now as it has been for more than 60 years. Consult the nearby, long-experienced Page Fence engineering and erecting firm, which will submit cost estimates without obligation. Name and address will be sent with illustrated fence data on request.

Write to PAGE FENCE ASSOCIATION in Monessen, Pa., Atlanta, Bridgeport, Chicago, Denver, Detroit, Los Angeles, Philadelphia, New York or San Francisco.

PRODUCT OF PAGE STEEL & WIRE DIVISION OF AMERICAN CHAIN & CABLE COMPANY, INC.

be extremely pleasing to all of you who have labored so intensely to obtain these results.

George J. Hanks, Chairman
South Penn Oil Co.
Bradford, Pa.

No Profits, No Progress

"In a modern industrial society, corporate profits must be considered largely as corporate savings from which production can be increased.

"The foes of our free-enterprise system are well aware the best way to kill off those things which have made this country the most productive in the world is to deprive industry of the earnings necessary to provide and attract the capital which is needed."

S. A. Swensrud, president, Gulf Oil Corp., addressing the St. Louis Chamber of Commerce.

Planned Economy—for Others

"I have little use for the advocates of a planned economy in which everything is planned except economy. And I find myself very impatient with those opportunists who, under cover of a national emergency, can think up a dozen sacrifices a day that it wouldn't hurt some **OTHER** fellow to make under their direction."

John G. Pew, vice president of Sun Oil Co., addressing the Pennsylvania Petroleum Association, Mount Pocono, Pa.

On Government Employes . . .

"I have been Secretary of Commerce for more than 4 years, and during that time I have made a conscientious effort to know as many of the people in my department as I could. I have dealt with a great many of them in my daily work. I have met with almost all retiring employes during those 4 years, and presented special awards to over 600 of them. They have talked freely of their interests and aspiration.

"My experience has convinced me that it would be hard, if not impossible, to find a comparable aggregate of talent and diligence in any of our great industrial concerns."

Secretary of Commerce Charles Sawyer, addressing the American Marketing Association, Washington.

It Takes Skill to Stay Put

"Today the gas industry in the United States is facing the most serious challenge in its history.

"We have surged upward from a small and conservative local industry to one of great national importance. The eyes of the nation are upon us. We

COMPENSATES FOR VESSEL TAPPING INACCURACIES

•

SAVES INSTALLATION TIME

•

REDUCES GAGE STRESSES

Another **PENBERTHY** *First*

An important new feature now available on all Penberthy drop forged steel gage valves is the "floating shank" . . . an improvement that has money-saving advantages to many users of liquid level and water gages.

The "floating shank" compensates for inaccuracies in the center-to-center distance of the tapped holes in the vessel on which the gage is mounted. The variation can be as much as 3/8". It provides a mounting flexibility not elsewhere obtainable . . . it saves time during installation of the gage . . . it eliminates stresses that are often induced during mounting.

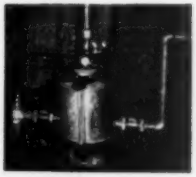
The Penberthy "Floating Shank" can be had at slight additional cost . . . specify it on your next order for Penberthy drop forged steel (or alloy) gage valves.

4449

PENBERTHY INJECTOR COMPANY
DIVISION OF THE BUFFALO-ECLIPSE CORPORATION
Detroit 2, Michigan
Established 1886 *Canadian Plant, Windsor, Ontario*

OTHER PENBERTHY PRODUCTS

PENBERTHY CYCLING JET PUMPS



Automatically operated by air, gas or steam pressure . . . Will pump without clogging any liquid that will flow through pipes. Ask for Bulletin 5030.

PENBERTHY EXPLOSION-PROOF SUMP PUMPS

Motor and switch totally enclosed. Underwriter approved for Class 1, Group D, and Class 2, Groups E, F and G hazardous location. Made of copper and bronze throughout. Ask for Bulletin 4929.

PENBERTHY EJECTORS

A simple jet pump operated by air, water or steam. Needs no lubrication . . . will not get out of order. Ask for Bulletin 5080.

Inside Canadian Oil

Recoverable crude reserves in Western Canada's oil fields have reached an estimated 1.4 billion barrels . . .

The Canadian Bank of Commerce—and its "banker-geologist" team—are equipped to give *efficient* assistance, based on *practical* experience, in problems concerned with Canadian oil financing. Our services have proved of value to many successful oil men. They can be of value to *you.*

Our brochure "For Oil and Allied Industries" contains information on leases and reservations, conservation, taxation, customs and immigration regulations, field data and other matters of importance to any operator interested in the Canadian oil and gas producing picture. Write for your copy to

Petroleum and Natural Gas Division
The Canadian Bank of Commerce
809 Centre Street, Calgary, Alberta

The Canadian Bank of Commerce

HEAD OFFICE: TORONTO

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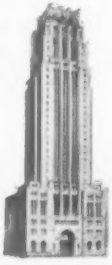
More than 600 Branches across Canada



stand on a summit of public acceptance.

"Every mountain climber knows that when a summit is reached, there's still plenty of danger—on all sides! It's not easy to reach the top, and merely to stay on top requires skill, experience, determination and hard work."

Charles E. Bennett, president, Manufacturers Light & Heat Co., speaking in Atlantic City.

CALENDAR OF EVENTS

NOV.

17-18 American Institute of Electrical Engineers, subcommittee on electrically operated recording and controlling instruments, technical conference Benjamin Franklin Hotel, Philadelphia.

20-21 National Association of Corrosion Engineers, western region, second annual corrosion conference, Biltmore Hotel, Los Angeles.

20-22 Instrument Maintenance Short Course jointly sponsored by Southern California Meter Association and Los Angeles Harbor Junior College.

21 Natural Gasoline Association of America, district meeting, Herring Hotel, Amarillo, Tex.

30-Dec. 5 American Society of Mechanical Engineers, Statler Hotel, New York City.

DEC.

1- 3 New Mexico Oil and Gas Association, annual meeting, Albuquerque.

1-6 American Society of Mechanical Engineers, twentieth National Exposition of Power and Mechanical Engineering, Grand Central Palace, New York.

4- 6 American Chemical Society, southwest regional meeting, Little Rock, Ark.

5- 6 Interstate Oil Compact Commission winter meeting, Wichita, Kans.

7-10 American Institute of Chemical Engineers, annual meeting, Hotel Cleveland (Hqs.) and Carter Hotel, Cleveland.

1953

JAN.

19-20 Independent Petroleum Association of America executive committee, quarterly meeting, The Campbell House, Lexington, Ky.

19-22 Plant Maintenance Conference, Public Auditorium, Cleveland.

FEB.

2- 4 Missouri Petroleum Association convention, President Hotel, St. Louis.

2-6 Corrosion short course, sponsored by National Association of Corrosion Engineers, University of California, Berkeley.

16-19 American Institute of Mining and Metallurgical Engineers, annual meeting, Statler Hotel, Los Angeles.

27 Natural Gasoline Association of America, regional meeting, Scharbauer Hotel, Midland, Tex.

Have you discovered these

Hidden Values

in Red-Strand wire rope?

You get 3 important, unseen values in Hercules *Red-Strand*.

The first is *extra endurance*.

The second is *consistently high performance*.

The third is complete *dependability*.

These values are made possible by Leschen's exacting insistence upon *higher-than-rated* quality . . . by precise, specialized manufacturing craftsmanship . . . and by the constant use of only the finest known grade of steel for long-lasting Hercules *Red-Strand* wire rope.

Service records prove these hidden values. Your records will too.

Higher operating profits may be yours with Hercules *Red-Strand* wire rope. Talk it over with your Leschen wire rope specialist . . . before you place your next rope order. Or, write for bulletin.

A. Leschen & Sons Rope Co., St. Louis 12, Missouri

In business *only* to make wire rope — *better* wire rope — since 1857.

DISTRIBUTORS IN ALL PRINCIPAL CITIES

THE VICTAULIC® METHOD OF PIPING

EASIEST WAY TO MAKE ENDS MEET

Sizes—¾" through 60"

Time and money-saving "Vic-Groover" Tools are only part of the *complete* Victaulic Method. Portable and easy-to-use "Vic-Groovers" are available in 9 sizes up thru 6", prepare pipe ends on the spot for quick easy hook-ups with Victaulic Couplings and Fittings, and they're automatic as to groove positioning and depth!

The Victaulic Method means a *complete* modern piping system: easy-to-install Victaulic Couplings that guarantee leak-proof, positive-locked connections with a union at every joint . . . a complete line of versatile Full-Flow Elbows, Tees, Reducers, and other streamlined Fittings unique in their wide adaptability . . . plus handy "Vic-Groover" Tools.

It's easy to see why the name "Victaulic" stands for world leadership in a fast, dependable piping method. Make that next job ALL VICTAULIC and prove to yourself that whether it's new construction . . . repairs . . . or alterations . . . the Victaulic Method solves every piping problem.

You'll find you save time, work, and dollars with Victaulic — *"the easiest way to make ends meet."* FOR YOUR OWN PROTECTION . . . make sure you get VICTAULIC!

Write today for Victaulic Catalog and Engineering Manual No. 44-8F.

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Export: Pipe Couplings, Inc., 30 Rockefeller Plaza, N. Y. 20, N. Y.

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MAR.

2- 6 American Society for Testing Materials, spring meeting, Statler Hotel, Detroit.

4- 6 American Petroleum Institute, division of production, Southwestern district spring meeting, Hilton Hotel, Fort Worth.

8-11 American Institute of Chemical Engineers, Buena Vista Hotel, Biloxi, Miss.

15-17 American Petroleum Institute, division of production, Eastern district spring meeting, William Penn Hotel, Pittsburgh.

15-19 American Institute of Mining and Metallurgical Engineers, annual joint meeting of petroleum, metals, and mining branches, Statler Hotel, Los Angeles.

16-20 National Association of Corrosion Engineers, ninth annual conference and exhibition, Hotel Sherman, Chicago.

18-20 American Petroleum Institute, division of production, Mid-Continent district meeting Mayo Hotel, Tulsa.

23-25 Western Petroleum Refiners Association, annual meeting, Plaza Hotel, San Antonio, Tex.

23-26 American Association of Petroleum Geologists, Society of Economic Paleontologists and Mineralogists, and Society of Exploration Geophysicists, joint annual meeting, Sam Houston Coliseum, Houston.

30-31 Texas Independent Producers and Royalty Owners Association, annual meeting, San Antonio.

30-Apr. 1 Mid-West Gas Association, Broadmoor Hotel, Colorado Springs, Colo.

APR.

8-10 American Petroleum Institute, division of production, Eastern district meeting, William Penn Hotel, Pittsburgh.

15-17 National Petroleum Association, mid-year meeting, Cleveland.

21-23 Southwestern Gas Measurement Short Course, University of Oklahoma, Norman.

24-25 Interstate Oil Compact Commission, 1953 spring meeting, Roosevelt Hotel, New Orleans.

26-29 American Institute of Chemical Engineers, Chemical Institute of Canada, joint meeting, Royal York Hotel, Toronto, Ont.

27-28 Independent Petroleum Association of America, mid-year meeting, Jefferson Hotel, St. Louis.

Apr. 29-May 1 Natural Gasoline Association of America, annual convention, Rice Hotel, Houston.

MAY

4- 5 American Petroleum Institute, division of marketing, midyear meeting, Baker Hotel, Dallas.

7-8 American Petroleum Institute, Rocky Mountain district, Division of Production, spring meeting, Gladstone Hotel, Casper.

11-13 Southern Gas Association, Jung Hotel, Hotel, New Orleans.

14-23 International Petroleum Exposition, Tulsa.

24-27 American Gas Association, production and chemical conference, Hotel New Yorker, New York City.

28-29 Natural Gas and Petroleum Association of Canada, London, Ont.

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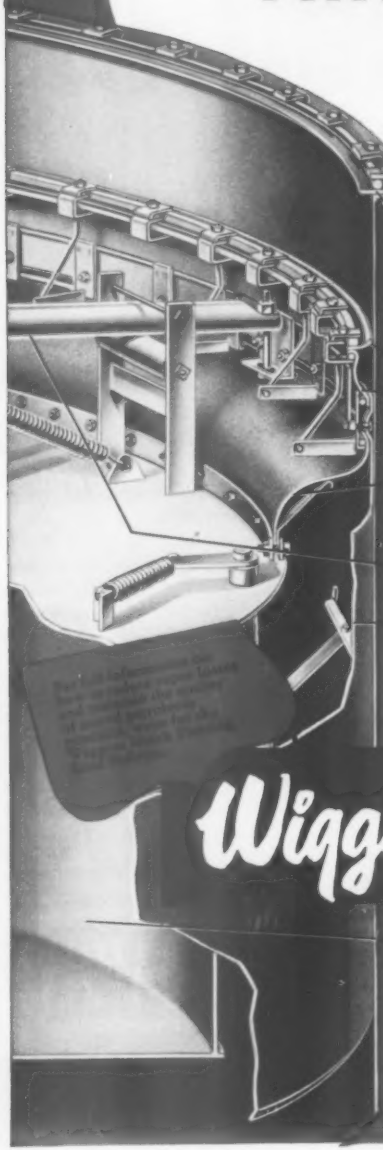

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JOURNALLY Speaking

Water Want

WHAT between the drought in the Southwest and the OPS ceilings, water is more valuable than oil in some places. At least a tale comes out of Texas that up in the Panhandle a farmer has got rich selling water to oil companies. It seems he owns a spring which is the only water available for miles around, and oil operators in the vicinity pay him fancy prices to let them pipe the water to their drilling sites. This farmer has 11 wells on his property, but he claims the water brings him more income than the oil.

If this situation gets general it might pay to get out of the oil business and into the water business. Out on the Pacific atolls during the war the Navy made drinking water out of sea water, but it took a gallon of oil to produce a barrel of water. This might not be a bad trade in West Texas, but the catch is that you have to have an ocean nearby to start with.

Cats, Rats, and Science

THE letters-to-the-editor column of a science magazine has been carrying a running debate over the way newspapers report science news. Many of the letters are from scientists who complain that reporters don't get the whole story, don't interpret the facts correctly, and twist things around in an effort to get a popular "angle."

One public-health researcher, for example, wrote that he once made the factual statement that there are about as many cats as rats in the city but cats don't eat many rats ordinarily. The story came out with the headline: "Scientist Blames Lazy Cats for City's Lag in Rat Race." This got him in dutch with all cat lovers.

There were other examples, less amusing and more serious. But some contributors rose to the defense of the journalistic profession, laying much of the blame on the scientists themselves for not giving the reporters complete information and not taking the trouble to explain all the background and significance of the development in question. Some even had a few good words for the attempt to "popularize" science as a way to give the general public at least a smattering of scientific information.

On the Big Yellow Book our problem is a little different—but not too much. Our staff writers know quite a bit about the oil industry, but nobody knows just all about it, and the industry is becoming so technical, and so ramified into a wide diversity of sciences, that our men frequently find themselves over their heads when talking with an expert on some new and esoteric line of research.

This raises the problem: If our own men, whose business it is to keep up with new developments, can't understand some of the latest discoveries of science and can't speak the language of all the diverse sorts of researchers, what about the harassed, busy, operating oil man? What will he get out of a verbatim report in a scientist's language?

So we try to "popularize" some of our articles just a little bit with the idea of translating from laboratory language to operating language and in the hope of inducing the average oil man to read far enough to be able to tell whether or not the data can be applied to his problem. Of course we run the risk of offending the sensibilities of some of the pure scientists, but we try not to get as far off the beam as the cat-and-rat incident.

Can Music

OIL has already got a foothold in the fine arts through water colors and oil paintings, and now it is breaking into music. We see by the papers that a young Chicago composer has written a piano concerto about an oil can. It was inspired by a problem in differential calculus about the cylindrical and conical parts of an oil can, and is divided into three parts: "cylindrical prelude," "conical arietta," and "differential fugue." We are informed that the composition is "in the modern idiom," which makes us wonder if it is anything like that "Cement Mixer" number that was so popular with the hep-cat set a few years back.

Henry D. Ralph

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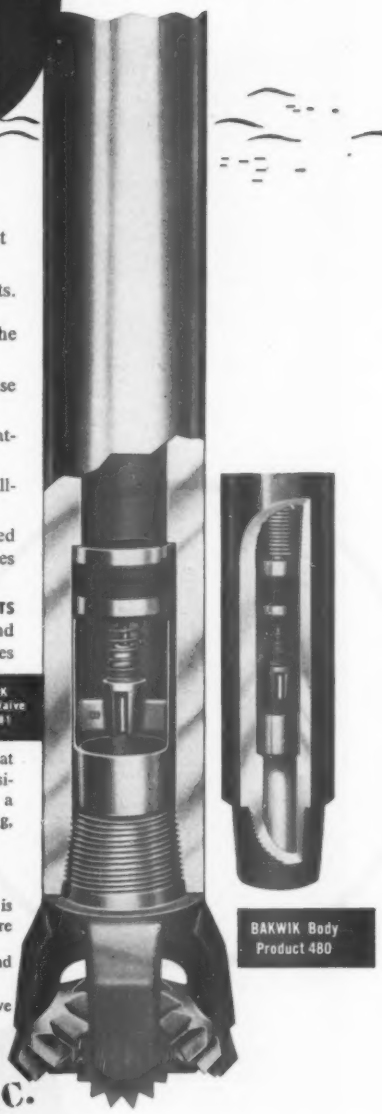

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How oil can get what it wants was outlined at the A.P.I.

SOME pretty big tasks were outlined for the oil industry during the coming years at the annual meeting of the American Petroleum Institute in Chicago last week.

It was a forward-looking gathering, and its unofficial theme was progress, a theme which ran through all division and group discussions. This is not a new theme for the progressive oil industry, but this year it had a different overtone.

A good many times in the past the oil industry's gatherings revolved around the question of what the Government would do to it or allow it to do for itself. This year the overtone was that the industry can answer these questions by providing the leadership so desperately needed in today's world and by assisting governments to provide the conditions under which the oil industry can thrive and under which the free world wants to live.

IN bare statement this sounds like just another high-blown, inspirational lecture, but speaker after speaker spelled out specific and concrete steps which can be taken now by large and small units in every division of the industry. Together they form a pattern for maintaining good business for the near future while building a solid foundation for growth, service, and understanding during the next generation.

In brief, the proposition laid before the A.P.I. is this: Oil is no longer just a private enterprise but has become an industry affected with a public interest. As such it owes a duty to the public to maintain the highest standards of service and to keep the public informed of its activities. But beyond this it has a responsibility to provide leadership—statesmanship—not only within the oil industry but to help solve economic, social, and political problems which perplex the public.

This is a challenge to oil men to think beyond their own business problems and take a hand in Government, not, as so often in the past, on the defense, complaining, protesting, or petitioning, but as leaders showing the way for all industry and for the general public and its political officials.

THIS is really a practical program, when broken down into the specific suggestions offered at the meeting. It boils down to doing many little things to keep the industry dynamic and competitive and to extend into other fields the type of positive and forward thinking which has made the American oil industry what it is.

In short, the industry can get the kind of economic environment, public understanding, and international conditions it desires if it takes the lead in formulating them. This requires a singleness of purpose, a cooperative industry, and a willingness to serve the public beyond the mere business of supplying oil.

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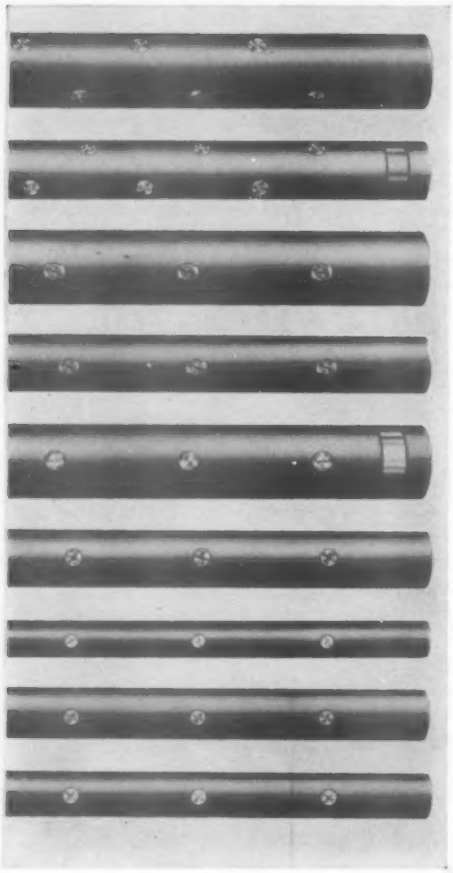

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THIS WEEK

HOW BIG CAN IT GET? . . . Registrations at the American Petroleum Institute's thirty-second annual meeting soared to a new record, closely approaching 6,400. Industry representatives came from 42 states and 8 foreign countries, with a heavy registration from Canada. Optimism and confidence permeated the entire meeting. Here is the registration desk as workers were swamped early in the week.

A.P.I.—Thirty-second annual meeting drew more than 6,300 oil men to Chicago last week. . . . Annual meetings for 1953 and 1954 also scheduled for Chicago with 1955 meeting planned for San Francisco. . . . ¶Technical and general sessions outlined big programs of work for the future, but a note of optimism and confidence permeated the entire meeting. . . .

. . . **Forecasts** . . . There will be bumps on the road ahead, but the trend of the oil business is upward, several A.P.I. speakers predicted. . . . ¶Domestic and foreign demand for petroleum products will increase steadily, but at a lower rate than recently, both short and long range. . . . Industry will be able to find and supply all oil and gas needed if permitted to function as in the past. . . .

. . . **Government** . . . A.P.I. speakers anticipate improved economic climate for business, but warn that change in administration does not assure it automatically. . . . Oil men urged to take active part in formulation and administration of government policies. . . .

. . . **Refining** . . . Brass-tacks approach to evaporation-loss problem seen contributing to new improved methods for evaluating and preventing product waste. . . . Theoretical and practical data combined to form basis for equations. . . . Dollars and cents angle will help refiners choose best types of storage in the future. . . .

. . . **Supply and Demand** . . . The industry will have as much reserve cushion 15 years hence as at present, A.P.I. told. . . . Petroleum demand increase of 39 per cent seen by 1967 in this country. . . . Important production gains for Gulf Coast and West Texas seen. . . .

. . . **Public Relations** . . . O.I.I.C. program continued with enlarged budget. . . . A.P.I. gets proof its program is bringing results in better press and general understanding. . . .

. . . **Reserves** . . . How to finance reserve oil capacity as defense standby recognized by several speakers as most perplexing future problem. . . . Many say it will be impossible under present price and tax policies. . . . They point out that capacity is now adequate for present needs. . . . Chapman calls for new inducement to solve the problem. . . .

. . . **Research** . . . A.P.I. celebrates twenty-fifth year of fundamental research efforts. . . . Projects on origin, recovery, composition and properties of petroleum provide broadening basis of understanding. . . . Pure research seen as important spur to commercial applications of improved technologies. . . .

INTERNATIONAL.—Thirteen companies compete in surprisingly heavy rush for best-looking Peruvian acreage with the opening period for concession applications under the country's new oil law. . . . Applications cover about 9,800,000 acres—mostly in the Sechura Desert, the most promising wildcatting territory in Peru. . . . ¶SEREPT, a French Government-backed company, strikes oil in Tunisia about 78 miles southwest of Tunis. . . . Well reportedly found the pay at about 1,800 ft. . . .

ACTIVITY.—Production of crude and lease condensate averaged 6,640,375 bbl. daily for week ended November 8, up 99,075 bbl. daily from previous week. . . . ¶Total well completions for the week dropped 34 wells to 879. . . . Wildcat completions totaled 217 wells compared with 234 for previous week and 201 for corresponding week last year. . . . ¶Rotary rigs operating in United States increased 35 rigs during the week ended November 10 to 2,627. . . .

TRENDS.—Major product stock changes for 5-week period ended November 8 were similar to last year's changes. . . . Stocks of four products gained 805,000 bbl. this year compared with an increase of 380,000 bbl. in the same period last year. . . . ¶Refinery runs averaged 6,888,000 bbl. daily for last 5 weeks, up 6.0 per cent for same period in 1951. . . .

MEMBERS OF THE PUBLIC-RELATIONS committee of the A.P.I. board of directors. Clockwise from the far left are Jack McKenzie, A.P.I., New York; Hines H. Baker, Humble Oil & Refining Co., Houston; Maston Nixon, Southern Minerals Corp., Corpus Christi; A. C. Mattei, Honolulu Oil Corp., San Francisco; L. S. Wescoat, Pure Oil Co., Chicago; W. Alton Jones, Cities Service Oil Co., New York; and, at left front, T. H. Barton, Lion Oil Co., El Dorado, Ark. A picture of other members of the committee appears on page 245.

Record Meeting Held

Limited optimism characterizes the thirty-second annual A.P.I. conclave; defense needs constitute biggest job

CHICAGO.—All eyes were on the future as more than 6,000 oil men met here for the thirty-second annual meeting of the American Petroleum Institute November 10-13.

What they saw was a mixed outlook, reassuring for the most part but tinged with warnings, responsibilities, and plenty of hard work ahead.

Little time was spent in discussing achievements of the past, though the oil industry got some bouquets for its accomplishments in expanding production to meet all needs during the emergency conditions of the past few years. The record of past performances was reviewed chiefly for the purpose of pointing the way to the future.

The results of the recent national election, generally interpreted as promising a more favorable economic climate for business, gave an optimistic overtone to the entire meeting, reflected both in the formal papers and in corridor discussion.

What is expected . . . The consensus was that the industry will continue to prosper and expand—provided it exercises a new high order of industrial statesmanship in working out the problems of relationships with the governments and the communities with which its future is intimately involved.

There were several formal economic forecasts on the program, and they agreed that the demand for petroleum products throughout the free world will continue to expand both in the short-range and long-range periods, though some ups and downs and some rough spots are anticipated. And no one doubted that the industry will be able to find and deliver the oil and gas needed provided it is given a chance to operate as it has in the past.

Building a reserve capacity as a standby for national defense was recognized as one of the knottiest problems ahead, and tied in with this is the problem of how the industry will obtain new funds for expansion under the present high tax rates.

Industry responsible . . . Throughout the discussion of these and many other problems ran the persistent theme that the industry itself must take the lead in finding and applying solutions, that the oil industry, as one of the largest in the world and as one of the most essential to the ordinary citizen and to the defense of the free world, must assume the responsibility of leadership.

Suggestions for doing this included such things as:

. . . Intensifying the campaign to gain public understanding of how the industry operates.

. . . Strengthening unity within the industry by removing points of irritation among competitors.

. . . Improving management methods in big corporations to keep them progressive and to develop strong leadership.

. . . Expanding the many research projects of the industry to make oil more efficient and more useful.

. . . Doing many things to maintain the industry's position as a dynamic and constructive force in the world's economy.

Financing a problem . . . How to finance the tremendous expansion of the oil industry which will be required in the future is one of our most serious problems, Frank M. Porter declared in making his annual report as president.

While some in the industry foresee the possibility of surpluses in the near future, the requirements of defense of the free world call for continued expansion of major petroleum facilities and the carrying of excess capacities in production, refining, and transportation, Porter said.

How to induce the industry to go beyond the limits of profit alone in the expansion and reserve-capacity program has not yet been solved, the A.P.I. head admitted, adding that the present high rate of corporate taxation makes it almost impossible for the industry to finance such a program by itself and threatens to destroy the social and economic structure of the country.

The Journal's Coverage

This first-hand report of the thirty-second annual meeting of the American Petroleum Institute in Chicago is brought to you by these members of the Journal staff in attendance: C. O. Willson, Kenneth B. Barnes, Henry D. Ralph, George Weber, and Paul Reed. Petroleo Interamericano, Latin-American affiliate of The Oil and Gas Journal, is represented by Oscar B. Irizarry, editor.

Porter Reelected by A.P.I.

CHICAGO.—Frank M. Porter, president of Fain-Porter Drilling Co., Oklahoma City, was reelected president, and L. S. Wescoat, president of Pure Oil Co., Chicago, was reelected chairman of the board of the A.P.I.

P. C. Spencer, president of Sinclair Oil Corp., New York, was reelected vice president for transportation. New vice presidents elected were John G. Pew, vice president of Sun Oil Co., Philadelphia, production; John G. Newton, vice president of Magnolia Petroleum Co., Beaumont, refining; and Robert M. Bartlett, vice president of

Gulf Oil Corp., Pittsburgh, marketing.

B. Brewster Jennings, president of Socony-Vacuum Oil Co., Inc., New York, was reelected treasurer, and Lacey Walker, New York, was reelected secretary.

New directors elected by the A.P.I. appear on page 255.

Oil's Record Lauded

Chapman says its accomplishments "unbelievable," but it still faces tough job of building up its reserve capacity

CHICAGO.—The oil industry's record of achieving the national-defense goals outlined for it by the Government 2 years ago is almost unbelievable, the American Petroleum Institute was told by Oscar L. Chapman, Secretary of the Interior and Petroleum Administrator for Defense.

The industry has fulfilled two of its three goals completely, but faces great problems in the remaining request to build up reserve capacity for a possible world war, he said.

The first job, after the Korean outbreak in the summer of 1950, was to insure enough oil to meet all vital military needs of the free world, and the second was to meet all essential civilian demands. The industry met those fully, under most difficult conditions of materials shortages and the Iranian shutdown, he said.

But, Chapman continued, there is real concern over the long-range problem of oil in defense.

Chapman said he had no clear solution to the problem. But eventually, he said, the profit incentive alone might prove inadequate, requiring some other inducement.

His only suggestion for a reserve fuel supply was to press the program for synthetic liquid fuels. He seriously believes, he said, that the time is near when private industry should think of attacking the problem on a commercial basis.

Industry's job . . . The oil industry's welfare during the next quarter-century depends on how well it answers mankind's aspiration for peace and freedom and end to want, T. S. Petersen, president of Standard Oil Co. of California, declared at the closing session of the A.P.I. meeting.

The industry can do this by remaining dynamic, expanding, competitive, and by contributing to the wellbeing of the communities where it operates, he said.

In 1975 we shall need more than twice the volume of petroleum we produced in 1950, Petersen said, but the industry can provide it if it continues to make technological advances which improve its efficiency in discovery, production, refining, and transportation.

By 1975 oil may face strong competition from other energy sources, such as atomic energy or liquid fuels from shale or coal, but this, Petersen said, "is heartening to the future of a mechanical civilization. Free competition among energy sources will keep costs low. Low costs will mean wider use. And the wider the use of energy, the faster our economy and technology will grow."

Foreign outlook . . . The future of American petroleum operations abroad may well play a leading role in the global conflict between freedom and Soviet imperialism, he said, adding:

"The job ahead is too big for our foreign friends to handle alone; they lack both the capital and the technical skills. Private American oil companies already are setting the pattern for aid to our free allies in the fields of Saudi Arabia, Kuwait, and other areas. In so doing we are working directly to bulwark the enlightened aspects of our foreign policy. In short, we are building freedom abroad.

"We are also building there a great intangible: Good will for America's future. We have added a sense of social responsibility which is new in international commerce.

"We do not pretend to be selfless. But neither are we merely opportunistic. We like freedom and we like dealing fairly with free peoples."

What lies ahead . . . Specific prediction of what things will be like 25 years from now may sound like science fiction, Petersen said, but he declared:

"This I know: Our future to a great degree will depend on how vigorously we hold to the principles that made our past. We can consolidate our economic revolution and meet the expanding needs of the next quarter-century only if our economy retains its dynamic self-sufficiency.

"We must, at all costs, retain those features of a free economy which have made American industry great: the customer's free choice of goods, free competition for the customer's favor, the presence of a profit incentive so that men will continue to invest their savings in the production of goods."

Bigness needed . . . Petersen ended his address with a defense of big business units, saying that in many industries some companies grow very big because they do a big job which could not be done in any other way.

"Bigness," he said, "along with efficiency and productivity, is a prime essential to maintain the momentum of our economic revolution, a key to the dynamic economy of the next quarter-century.

"I firmly believe that, in the next 25 years, we shall hear less and less from those who belabor business for being big—those to whom bigness is automatically badness. There seems to me to be a growing awareness throughout the country that America's greatness is based substantially on the freedom of every man and every business to grow to the fullest possible stature. We need bigness in all of its connotations if we would lead the world to peace and freedom."

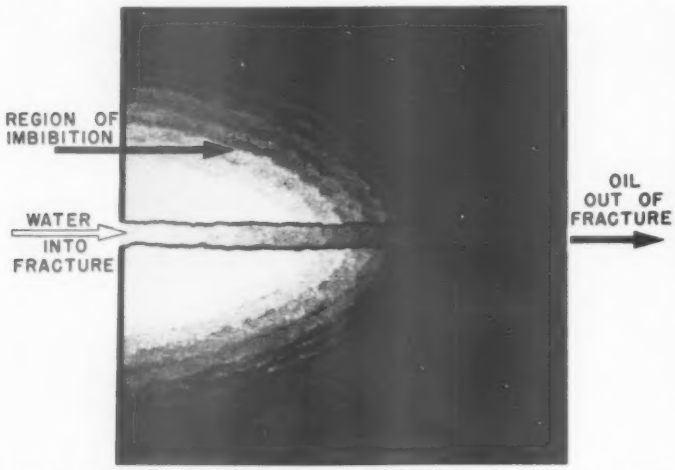
Chairman's address . . . The A.P.I. is not so much a business meeting as a convocation dedicated by the profit motive to the welfare and progress of mankind, L. S. Wescoat, president of Pure Oil Co., told the general session in making his report as chairman of the Institute's board of directors.

In the 33 years since the A.P.I. was established it has adhered to its objective to promote the progress of petroleum in a peaceful world, and it does this in a hundred different ways, he said.

The A.P.I. is a clearing house and repository for the research and ideas of the industry, and a forum for the dissemination of industry know-how and scientific truth.

Millions of dollars have been saved the industry through the Institute's work on standardization of equipment, getting "a fair shake" in the burden of taxation, conducting fundamental research, collecting statistics, and many other activities, he said.

Meeting dates set . . . The A.P.I. set dates for its next three annual meetings as follows: 1953—Chicago, November 9-12; 1954—Chicago, November 8-11; 1955—San Francisco, November 14-17.



THIS IS IMBIBITION, now being tried experimentally by Atlantic Refining Co. in Driver field of Glasscock County in West Texas. The illustrative drawing shows how water, being absorbed by the rock, displaces crude oil which moves down the fracture.

PROOF THAT IT WORKS is shown in this photograph. Oil, displaced by imbibed water, appears on the core's surface in globules.

How Imbibition Works

New secondary-recovery technique visualizes soaking-up of water by producing formation, freeing trapped crude

CHICAGO.—The new method or new concept of oil-recovery mechanism known as water imbibition was shown here at the Chicago A.P.I. meeting to have a displacement efficiency on Spraberry oil sand ranging from 0 to 67 per cent oil recovery and averaging 31 per cent.

If water-imbibition displacement should work in the Spraberry, these figures of Atlantic Refining Co. mean that the ultimate oil recovery would be about three times the natural displacement recovery.

The 39 core samples making up the tests were run at the Dallas research laboratories of Atlantic Refining Co. The data were presented at a Production Division session by Dr. E. R. Brownscombe and Dr. A. B. Dyes, both of Atlantic. *(Text of their paper appears in this issue, beginning on page 264.)*

A vastly improved recovery mechanism over nature's own internal gas-expansion or displacement process is badly needed for West Texas' Spraberry trend. Only one-third of the proven Spraberry has been drilled up because engineers now estimate that ultimate recovery of the Spraberry under the natural conditions will average only about 600 bbl. per acre. Development work has slowed considerably; active rotary rigs are down from 260 a few month ago to about 60 now.

First disclosure of Atlantic's water-imbibition process and its possible Spraberry application came this summer when the company made application to the Texas Railroad Commission for experimental trial in the upper Spraberry formation, using three injection wells on its W. M. Schrock lease in Driver field, Glasscock County. *(Testimony at this hearing was presented in The Oil and Gas Journal, August 11, page 72.)*

A second request for permission to initiate a pilot water-imbibition project was made this month by Tex Harvey Oil Co. in Tex Harvey field of the Spraberry trend. This project will include an area of 1,600 acres. The project contemplates input of 200 bbl. of water per day per well, removal of gas-oil ratio restrictions, and granting of a lease allowable.

Physical concept . . . The Atlantic researchers apparently were thinking specifically of Spraberry needs when they started their work which led to the experimental application of water imbibition in Driver field.

In their Chicago A.P.I. paper they pointed out that in the Spraberry reservoir the oil is stored in a very tight matrix, with virtually all the permeability concentrated in a large number of fractures.

These native fractures, interconnected, appear to be 3 to 4 ft. apart, and from micrometer measurements made on cores by Sohio Petroleum Co., the average width seems to be about 0.002 in. The formation might be compared to a section of huge building stones, lying in solid blocks but broken or fractured every 3 to 4 ft.

The Atlantic men pointed out that because of this fractured condition conventional water flooding is out of the question. Channeling and bypassing through the fractures would be extremely serious. Likewise, this channeling would be even more troublesome for any kind of gas-injection operation.

Thus, the Spraberry problem was to find some way to energize, drive, or displace the oil from this tight matrix rock.

Fractures may help . . . But these troublesome fractures may prove to be the very "key" or foundation of the water-imbibition application to the Spraberry.

The Atlantic group got the idea that if these fractures were filled with water, the natural capillary attraction of the fine pores in the matrix rock would imbibe or soak the water into the body of the material, from the fractures as a point of entry.

To check this, in their early quali-

EDITORIAL BOARD for Drilling and Production Practice, Division of Production, meeting for an early session. Left to right are: Earl G. Gaylord, California Research Corp., San Francisco; C. E. Beecher, Cities Service Oil Co., Bartlesville; John R. Suman, Standard Oil Co. (N. J.), New York; R. O. Garrett, Arkansas Fuel Oil Co., Shreveport; Alden Donnelly, Honolulu Oil Corp., Midland; Glenn Stearns, British-American Oil Producing Co., Dallas; William H. Strang, A.P.I., Dallas; D. V. Carter, Magnolia Petroleum Co., Dallas; W. L. McCloy, Jr., Sohio Petroleum Co., Oklahoma City; C. A. Warner, Houston Oil Co., Houston; C. A. Reistle, Jr., Humble Oil & Refining Co., Houston; J. E. Brantly, Petroleum Administration for Defense, Washington; and Milan G. Arthur, Union Oil Co. of California, Los Angeles. This session was one of 127 board and committee meetings held during this biggest of all A.P.I. meetings.

tative tests they dropped pieces of the Spraberry matrix saturated with oil into a beaker of water. Droplets of oil soon oozed out from inside the sand, and rapidly collected as globules over the surface of the sample. This meant that the water was imbibing or soaking into the rock and that the oil was oozing out from the same surface in which the water was entering.

Two-way traffic flow . . . A simplified illustration of oil production by water imbibition, prepared by Atlantic for the A.P.I. meeting, is shown in the left photo on page 230.

Water is being injected into the fracture only. As water moves along the fracture some water continuously is being lost to the matrix by imbibition. As this water moves in, oil moves out. Thus water in the fracture is being replaced by oil, until the fracture downstream is completely filled with oil.

This is the simplest description of water imbibition—a theoretical single fracture where water is injected at one end and oil is taken from the other.

However, to understand the mechanism properly it is necessary to note that the process is capable of more than simple water travel down a one-way path, displacing oil ahead of it. Indeed, it appears that the water can actually soak into the tight sand in one direction and, as the water moves along this path displacing oil, the oil can literally turn backward and flow in the opposite direction through larger pores. This curious phenomenon is due to the simple circumstance that the imbibition in the first place occurs due to the capillary force or capillary attraction of the pores for water.

The two-way movement of water in one direction and the oil in the other direction (up to a direct backward reversal) seems to be proven by the simple experiment already referred to—that of dropping a piece of oil saturated core sample in a beaker of water. As the oil is imbibed or soaked inward into the core, the oil inside starts moving in the opposite direction and finally pops out to surface and forms the droplets of oil.

Travel rate . . . At the A.P.I. meeting the Atlantic men described their studies of the travel of water via imbibition into the Spraberry cores. These studies involved X-rays of cores which had been saturated with opaque phenyl iodide.

When the results were adjusted to account for differences between laboratory and reservoir oil viscosities and the presence of free gas, connate water, etc., the tests showed that under Spraberry reservoir conditions the water would completely penetrate a matrix block 1 ft. thick within 6 months. It would even penetrate a block 6 ft. thick within 15 years, assuming 3-ft. penetration from two sides.

If the reservoir performance should be as good as their laboratory tests, the Atlantic men said, these rates of penetration are sufficient to be of economic application to the Spraberry.

At the Chicago meeting, Atlantic put forth a few other ideas on water imbibition which show it is different from conventional water flooding, particularly for Spraberry conditions with its interconnected vertical fractures. A characteristic of imbibition is that the producing water-oil ratio is a function both of rate of water injection and of the natural imbibition rate. In conventional water flooding, the producing water-oil ratio is determined by the degree of depletion.

In the case of field operations with the water imbibition process, if the rate of natural imbibition into the matrix were greater than the injection rate, all of the water would soak into the matrix and only oil would reach the producing end of the fractures.

After water production begins at the output oil wells, it might prove desirable to increase the water-injection rate substantially, thus increasing the amount of water in the fractures. By putting more water in the fractures, the area of contact would be increased between the matrix and the water in the fractures, provided that the water-injection rate had been below the rate of natural imbibition. This later step-up in water input could be expected to increase oil production and extend economic life of the oil production, although the water stepup would, of course, increase the water-oil ratio.

Field application . . . Dr. Brownscombe and Dr. Dyes translated their laboratory data to field conditions for estimates for the upper Spraberry formation of the Driver area.

They calculated that sufficient water could be imbibed and would displace oil sufficiently so that a rate for producing wells could be maintained in the neighborhood of 100 bbl. of oil per day per well for several years,

PARTICIPANTS in A.P.I.-sponsored research projects celebrated 25 years of fundamental research on the origin and recovery of petroleum at a dinner November 9. At the speakers' table, left to right, are: John E. Sherborne, Union Oil Co. of California, Los Angeles; Howard G. Vesper, California Research Corp., San Francisco; Robert A. Millikan, California Institute of Technology, Pasadena; Frank M. Porter, A.P.I. president, New York; J. K. Roberts, Standard Oil Co. (Ind.); Lloyd E. Elkins, Stanolind Oil & Gas Co., Tulsa; William N. Lacey, Cal Tech.; E. G. Gaylord, California Research; B. H. Sage, Cal Tech.; and C. V. Millikan, Amerada Petroleum Corp., Tulsa.

with only moderate water production.

Later water production could be expected at increasing rates. They estimated that the ultimate recovery might be about three times the natural-depletion recovery.

How Research Helps

It benefits everybody, but much remains to be done

CHICAGO.—Production research by any company benefits the entire industry in the long run, Lloyd Elkins, head of production research in the Tulsa laboratories of Stanolind Oil & Gas Co., told a Division of Production session at the A.P.I. meeting here.

"Anything new in reservoir mechanics that aids recovery works for all because seldom can one operator apply it himself without demonstrating to many others the essence of his know-how," Elkins said. This is particularly true where unitization or cooperative operations are under consideration, "and this is required for almost any type of secondary-recovery process."

Many equipment items and oil-field specialty services are licensed to service companies which, in turn, serve the entire industry, he said.

Elkins said there has been an increase of more than 600 per cent in organized research in 15 years in seven production laboratories consulted in a nation-wide survey of research activities. He estimated that during the past 5 years organized research in the oil industry has doubled.

Tangible research benefits were listed by Elkins in the fields of well logging, drilling mechanics, drilling muds, cementing, well completions, pumping methods, corrosion, and reservoir mechanics.

Not too well known to people with operating responsibility, he said, is the almost Herculean task of research to develop adequate means of conducting model flow tests which will permit reliable evaluation of recovery processes in any type of reservoir.

What lies ahead . . . Looking to the future, Elkins pointed to some current oil-research objectives by asking a series of questions. These included:

. . . **"Would our geologists** and engineers be happy with a logging service that would directly or indirectly record everything in place that could be measured from cores brought to the surface?"

. . . **"What roughneck** or executive would not rejoice over the development of a bit that could be installed and replaced without pulling and running drill pipe?"

. . . **"Why not a drilling fluid** such that its filter cake of controlled thickness would set up hard at the right time with some triggering procedure and possibly serve some of the purposes of a string of casing?"

. . . **"Would it not be** of some advantage in some formations to have a means of automatically opening up tight streaks of pay and thus smooth out the permeability profile of a well?"

. . . **"Possibly some day,** and we hope not too far off, may we install the average equipment layout for an entire oil field from pipe-line outlet back to each casing shoe so it will be balanced electrically and so that steel will stay where we put it and not disappear into solution in underground waters?"

Electronic "Brains" Increasing

CHICAGO.—Use of high-speed calculating machines to solve problems in oil production is increasing, Dr. W. A. Bruce, of the research laboratories of Carter Oil Co., Tulsa, told a session of the Division of Production at the A.P.I. meeting here.

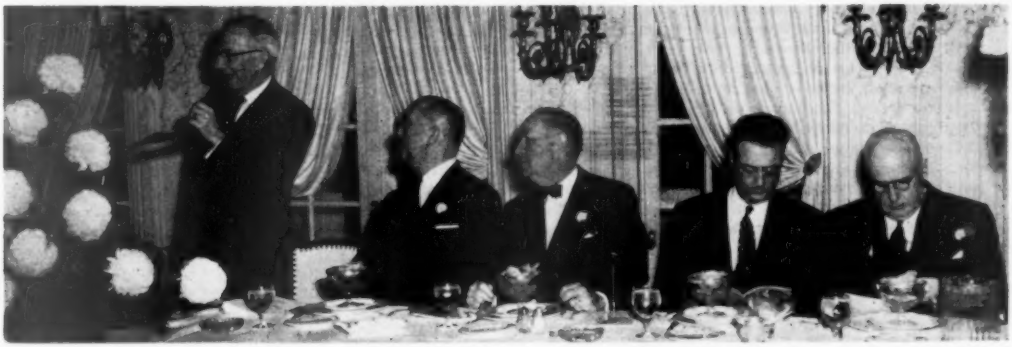
A number of oil companies recently obtained or will soon install card-program calculators, Bruce said. Some problems of calculating oil-reservoir performance require as many as 100 million arithmetic operations.

An example of such a difficult calculating problem is that presented by a pool operating with both a gas cap and water drive. Involved in the calculations are studies of present reservoir behavior and plans for future operation of the reservoir. Pertinent factors are water influx, gas injection, and gravity drainage. Application of all the technology now available to engineers would require this large number of calculations.

Dr. Bruce said that these giant "electronic brains," which for the last 6 years have been laboratory tools, are about to emerge as production models. So far they have been custom built and, before 1951, no two had been made alike. Each one has been made obsolete by by new developments before it could be finished. However, now several of these computing giants are in daily operation.

A number of companies offer them for sale and about 10 will be installed for defense, commercial, or government use this year.

Bruce's A.P.I. paper, entitled "Use of High-Speed Computing Machines for Oil-Production Problems," appears in this issue beginning on page 260.



AT THE HEAD TABLE for the Pipe Liners Club banquet are, left to right, R. B. McLaughlin, Texas Pipe Line Co., Houston, retiring president; O. F. Moore, Ohio Oil Co., Findlay, Ohio, new president; J. L. Latimer, Magnolia Petroleum Co., new vice president; Ralph K. Paine, Standard Oil Co. of California, San Francisco; and Fayette B. Dow, National Petroleum Association, Washington.

New Methods Outlined

Fully automatic pipe-line stations, product switching described; more new techniques ahead in transportation

CHICAGO.—Newly developed instruments mean that an increasing number of pipe-line functions now handled manually will be performed automatically or by remote control.

The A.P.I.'s Division of Transportation was told that the day is coming when even scraper-trap manipulations and the switching of batched products might be accomplished entirely by mechanical means.

Emphasis was given to the importance of basing construction practices on data periodically reported to the industry which reflect current pipeline procedures.

In looking forward to the continued expansion of petroleum transportation, attention was directed to the greater efficiencies possible with big-inch lines, more extensive instrumentation for overland pipe lines, and by use of the more-efficient new supertankers.

Automatic stations . . . Remote stations which are fully automatic and controlled simply by the pipe-line stream operate more satisfactorily than stations controlled from a remote point by an operator or dispatcher, S. S. Smith, Shell Oil Co., New York, told a session of the A.P.I. Transportation Division.

Smith said his company is now preparing to convert four stations to fully automatic operation after 2 years of remote-control operation. He mentioned that Standard Oil Co. of California, Phillips Petroleum Co., Shell Oil Co., Standard Oil Co. (Ind.), Sunray Pipe Line Co., and perhaps others are depending upon completely automatic stations which depend upon attendants only for housekeeping and maintenance.

Although there is yet no dependence upon complete automatic control of product takeoff without supervisory control, Smith cited the design for a pipe line not yet built in which four products would be handled automatically from the point of first pumping through all of the intermediate takeoff points and into the final terminal.

The intermediate points would be served by automatic equipment discriminating between products; products would be measured either on preset volumes or on tank gages in tankage, entirely without the presence of personnel.

Plantation Pipe Line Co. and Great Lakes Pipe Line Co. have done much to develop the application of electronics to products pipe lining, according to Smith.

To speed up truck loading in multiple-compartment trucks, Great Lakes has developed electronic counter mechanisms and gang switches. By the use of the new facilities it is possible that three products selected at will from any of the rack components can be simultaneously loaded, counted and the movement recorded on a single truck loading ticket or manifest in remotely controlled printers at a central point on the loading rank.

New tankers efficient . . . Higher operating efficiency has been achieved with new supertankers, said Brewster Jennings, president of Socony-Vacuum Oil Co., Inc., New York.

A 250,000-bbl. tanker today costs about $7,000,000, as against $2,000,000 for an 80,000-bbl. tanker in 1927. In the coastwise movement from Beaumont to New York, these tankers will make it possible to cut costs from 36 to 26 cents a barrel, he said.

Oil companies have been willing to turn over transportation to outsiders who have shown that they can do the job, in price and service, Jennings said. This has been particularly true with transport trucks.

With the exception of pipe lines, according to Jennings, outside carriers have entered every phase of oil transportation at advanced stages of development after oil companies pioneered the way.

New welding code . . . The new pipeline field welding code was explained by R. G. Strong, Natural Gas Pipeline Co. of America, Chicago, and J. G. Norton, Magnolia Pipe Line Co., Dallas, by a question and answer presentation.

The new code for standardizing and simplifying pipe-line welding has been prepared by the A.P.I.-A.G.A. joint welding committee after more than 3 years' work.

This committee, headed by Strong as chairman, represents five groups, each of which has four members. These groups are American Petroleum Institute, American Gas Association, Pipe Line Contractors Association, National Electric Manufacturers Association, and the pipe manufacturers.

The code will facilitate the application of uniform techniques for welding identical steels in pipe in all parts

of the country under all field conditions. Confusion and varying quality of work will be avoided which have resulted in the past from different methods specified by several companies.

Already the code's new specifications for field welding and radiographic inspection have been applied satisfactorily on several construction programs.

The specifications outline the entire procedure for welding, including bevels, welding speeds, number of beads, and the care of welding rods. It is also recognized that uniform methods for achieving clear, precise radiographs without doubtful shadows would facilitate interpretation and minimize rejection of welds.

Automatic welding, preheating, and inspection by Magnaflux and supersonic methods were not included in the code. Later when they have advanced they will be reconsidered for inclusion in the specifications.

Microwave Payout

Ellis cites 9-month amortization on equipment in remote station from labor saving alone; tanker future discussed

CHICAGO.—Savings in labor cost alone completely paid out the additional investment in microwave equipment to control a pumping station on an 85-mile products pipe line—and within 9 months—J. R. Ellis, of Sunray Pipe Line Co., told a Transportation Division session.

Ellis said that on the 8-in. Oklahoma products line it became necessary to increase the capacity by adding an intermediate booster station 32 miles from the initial station.

This booster station was equipped with microwave radio controls, which made it possible for station operators on duty at the initial pump station to observe operating conditions at the remote booster station.

These observations permit regulation of the pumping rates in a manner which insures operation of the pipe line at maximum throughput by utilization to best advantage of the power available at both the initial and booster stations, Ellis said.

The microwave radio system provides communication channels for the supervisory controls and for the telemetering equipment which makes the remote operation possible. *(Text of the Ellis paper may be found in this issue beginning on page 258.)*

Tankers in transportation . . . Ocean-tanker transportation has been found to be the most efficient means of transporting energy over long distances although frequently suffering the disadvantage of considerable circuity of routes, H. N. Emerson, Atlantic Refining Co., Philadelphia, told the pipeline group.

The author expressed apprehension over the expansion of the American-flag fleet because of competitive considerations not related directly to its technical proficiency.

"It appears that the future growth of the American tanker fleet will be determined largely by extraneous factors," he said. "These factors will relate to the f.o.b. price of the various fuels at point of origin; to distribution expenses beyond the point of line-haul destinations; to the development of new power sources such as oil or gas not adjacent to our coastal waters; to possible developments in the field of public power projects; to the relative spread between the capital and operating costs of foreign-flag and American-flag tankers; and to the possibility of marked improvements in the petroleum pipe-line field.

"All of these factors . . . relate to commercial matters . . . Although there will probably be a substantial increase in total energy consumed in the United States in the future, it is the author's opinion that American-flag tankers may not be able to secure the same percentage of the total movement as in the past.

"Nevertheless, the economics of the modern tanker as a carrier of energy demands that it receive the most careful consideration for all routes where its services could possibly be used," he said.

Stress problem . . . Flat spots in the wall of large-diameter pipe cause large local bending stresses when the pipe is placed under pressure. The sum of the bending stress caused by these spots and the nominal circumferential stress caused by pressure may easily exceed the yield strength of the steel and cause local plastic deformation, J. W. Lodge and G. K. Manning, of Battelle Memorial Institute, Columbus, Ohio, told the group.

The Lodge and Manning paper appears in this issue beginning on page 344.

Such flat spots may be formed after mill testing in a number of ways, and therefore, the authors pointed out, it is desirable to "proof-test adequately a pipe line before it is placed in service in a manner which is not hazardous to personnel or property."

Results, they said, also show that the bending stress caused by soil pressures varies somewhat over a period of a year. This suggests that the proof testing should be carried to a higher pressure than the maximum operating pressure. This difference between proof-testing pressure and maximum operating pressure should be greater than the 50 psi. now used for some pipe-line installations.

AT THE PIPE LINERS' banquet the photographer caught this group of operating men. Left to right are S. G. Loy, Humble Pipe Line Co., Houston; O. Q. Lomax, Humble Pipe Line Co., Houston; A. E. Pecore, Humble Pipe Line Co., Houston; John W. DeGroot, Tuscarora Oil Co., Ltd., Harrisburg, Pa.; C. C. Keane, Great Lakes Pipe Line Co., Kansas City; Grey Linsley, Great Lakes Pipe Line Co., Kansas City; William A. Bennett, Standard Oil Co. (Ind.), Chicago; Dean C. Glass, Pure Transportation Co., Chicago; and R. A. Kroenert, Great Lakes Pipe Line Co., Kansas City.

Too-Active Government

It should quit trying to run the show and limit itself to the job of referee, A.P.I. told; trend is the reverse

CHICAGO.—The Government should be the "umpire or referee, not the captain of the team," the Transportation Division of the A.P.I. was told by John S. Burchmore.

Burchmore, a member of the Chicago law firm of Walter, Burchmore & Belnap, told the transportation men that the proper role of Government is to administer the law and not the pipe-line carriers.

It should step in, he said, to prevent abuses, to right wrongs, to educate the ignorant, to make the rules of fair, honest conduct, and to enforce them, "but not to run the game or to insure success and prevent failure."

Burchmore said that no policy or program or point of view should be adopted or imposed merely upon the decision of the one who proposes it.

"This goes further than the well-known constitutional principle of separation of powers, or of prohibiting one person from having the dual role of prosecutor and judge," he said. "It means that no governmental agency with the duty or function of exploring avenues of improvement should at the same time have the power to impose a program upon the transportation agencies for whose improvement the exploration is made."

Trend in government . . . Burchmore paid tribute to the fairness of the Interstate Commerce Commission, pointing out that over the years it has not followed any idea of running transportation or attempting to improve upon the imagination or initiative or resourcefulness of management. The ICC was interested, he said, only with umpiring the universally accepted rules of the game, chiefly established by the Congress.

However, he warned that in recent years the climate of opinion in government circles outside the commission has "cultured a new idea (new, that is, to our form of government), although it is really as old as tyranny.

"This idea is that Government should initiate and manage, plan, and protect."

Burchmore cited opposition to the proposed jurisdiction of the transportation industry from the ICC to other governmental agencies.

"In considering the proposals of changes in jurisdiction and in methods," he said, "I urge the paramount principle of return to full acceptance of the doctrine that railroad managements, motor-carrier managements, and all other managements of business of transportation should have great responsibility, and very large freedom from interference, in the job of making the service meet the public's requirements and of insuring sound transportation at fair rates—this with the protection for the public, and for the carriers themselves, of a tribunal of high standing and experience, with authority limited to prescribing for the future only substitutes for those rates or practices found in fact to be undesirable and unlawful."

Public attitude . . . R. H. Lynch, Keystone Pipe Line Co., Philadelphia, citing proposed new controls on the pipe-line industry aimed at controlling or supervising the construction of lines, said that the things which provoke critical attitudes on the part of the general public and which engender the feeling "we need more regulation and control of our industry" are alarming.

"As more and more pipe lines are built throughout the country we are brought into contact with more and more people . . . As new lines are built the pipe lines cross the properties of more and more property owners, and, as a result, more people know about our existence and our methods."

Lynch said that every time a pipeline company makes a decision on a matter regarding crossing of property and amount to be paid that "you are making friends or providing a source of contention—not alone from your own pipe line, but for all pipe lines."

Moore Heads Pipe Liners

CHICAGO.—O. F. Moore, vice president and manager of Ohio Oil Co., Findlay, Ohio, was elected president of the Pipe Liners Club at the banquet in the crystal ball room of the Blackstone Hotel.

He succeeds R. B. McLaughlin, president of Texas Pipe Line Co. J. L. Latimer, president of Magnolia Petroleum Co., Dallas, was elected vice president, and Oliver C. Klinger, publisher of Oildom Publications, Houston, was named secretary-treasurer.

J. H. Wood, vice president and general manager, Atlantic Pipe Line Co., becomes a new member of the board of governors. Others on the board are McLaughlin, Latimer, Moore, Loren F. Kahle, deputy coordinator of transportation, Standard Oil Co. (N. J.), New York, and J. L. Burke, president of Service Pipe Line Co., Tulsa.

THE COMMITTEE ON FIRE PREVENTION is shown in session at the annual A.P.I. meeting in Chicago. Clockwise around the table are L. A. Tromley, Warren Petroleum Corp., Tulsa; E. E. Jurs, Shand & Jurs Co., Berkeley, Calif.; R. L. Davis, California-Texas Oil Co., Ltd., New York; P. C. Jurs, Shand & Jurs Co., Berkeley; J. A. Price, Phillips Petroleum Co., Bartlesville, Okla.; R. A. Randel, Shell Oil Co., Wood River, Ill.; W. E. Soden, Sun Oil Co., Philadelphia; Charles H. Bunn, Jr., Standard Oil Development Co., New York; R. T. Henderson, Sohio Petroleum Co., Whittier, Calif.; J. E. Hill, Union Oil Co., Los Angeles; F. G. Wilson, A.P.I., New York; C. D. Norris, The Texas Co., New York; S. D. Clithero, General Petroleum Corp., Los Angeles; C. H. Lindberg, Sinclair Pipe Line Co., Independence, Kans.; J. P. West, Sohio Pipe Line Co., St. Louis; R. N. Reed and E. G. Miller, Esso Standard Oil Co., Baton Rouge, La.; and J. L. Risinger, Socony-Vacuum Oil Co., Inc., New York.

MEMBERS OF THE Automotive Research Committee of the A.P.I. Division of Refining, who met immediately prior to the Institute's annual meeting. Left to right on the outside of the left table are: J. J. Mikita, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.; J. R. Sabina, Du Pont, Wilmington; William N. Finney, The Texas Co., New York; M. K. McLeod, Coordinating Research Council, New York; A. E. Cleveland, Ford Motor Co., Dearborn, Mich.; L. Raymond, Socony-Vacuum Oil Co., Inc., Paulsboro, N. J.; N. K. Anderson, Deep Rock Oil Corp., Cushing, Okla.; L. L. Davis, Continental Oil Co., Ponca City, Okla.; David E. Day, Richfield Oil Corp., Los Angeles; Jerry McAfee, Gulf Research & Development Co., Pittsburgh; L. O. Crockett, Gulf Oil Corp., Pittsburgh; and A. L. Clayden, Sun Oil Co., Philadelphia. Left table, inside: C. K. Viland, Tide Water Associated Oil Co., Associated, Calif.; Hugh A. Field, Atlantic Refining Co., Philadelphia; C. M. Ridgway and K. Boldt, both of Pure Oil Co., Crystal Lake, Ill.; W. P. Hilliker, Pan-Am Southern Corp., New Orleans; J. E. Taylor, Gulf Oil Corp., Pittsburgh; and J. G. Moxey, Jr., Sun Oil Co., Marcus Hook, Pa. Right table, inside: F. J. Sanders, Standard Oil Co. (Ohio), Cleveland; T. B. Rendel, Shell Oil Co., New York; F. W. McCurry, Derby Oil Co., Wichita, Kans.; F. I. L. Lawrence, Kendall Refining Co., Bradford, Pa.; W. W. Scheumann, Cities Service Research & Development Co., New York; and W. T. Reed and C. D. Miller, both of Battelle Memorial Institute, Columbus, Ohio. Right table, outside: William M. Holaday, Socony-Vacuum Oil Co., Inc., New York; Howard G. Vesper, California Research Corp., San Francisco; W. J. Sweeney, Standard Oil Development Co., New York; and H. D. Wilde, Humble Oil & Refining Co., Houston. John T. McCoy, Tide Water Associated Oil Co., Bayonne, N. J., not shown, presided at the meeting.

Demand Will Be Met

It will rise 39 per cent in next 15 years, but industry will meet it and add to reserves, too, refiners are told

CHICAGO.—The oil industry will deliver the oil to meet a constantly increasing demand for the next 3 years if it is given an environment of monetary stability, free prices, intelligent labor relationships and a sound highway-development program.

This conclusion was contained in a joint forecast covering the next 15 years presented before a session of the A.P.I. Division of Refining by John E. Swearingen and John W. Boatwright, both of Standard Oil Co. (Ind.).

The study was undertaken in two parts, with Swearingen, Indiana Standard's general manager of production, leading off with an analysis of the domestic industry's crude-oil potential for the next decade and a half.

Turning from the method of extrapolating past statistics on oil discovery, the authors concluded that a more reliable picture of our future oil production could be obtained from the opinions of the men who must find the new oil prospects to drill—the geologists and geophysicists. They therefore consulted oil-finding people who work in all of the major producing provinces of the country and based their forecast on the consensus of their views.

The estimates they obtained on future production potentials of the various areas were crosschecked with one another and were revised and adjusted to what they considered a mutually consistent basis and one not in conflict with such statistical evidence as could be employed.

Reserves to increase . . . During the next 15 years, we shall be finding oil faster than we shall be using it, they concluded.

The industry in 1967 will be producing about 8,000,000 bbl. of crude oil and 1,100,000 bbl. of natural-gas liquids per day—a total of 9,100,000 bbl. This represents an increase over present rates of about 2,200,000 bbl. per day, or about 33 per cent.

In order to reach this level of production, the industry must, in the next 15 years, find and develop approximately 49,000,000,000 bbl. of crude oil. This contrasts with the total cumulative production to date of 42 billion barrels, and total oil discovered to date (production plus proved reserves), of about 71 billion barrels.

The authors feel that not only will the industry achieve that production goal, but will have a comfortable margin of producing capacity over actual requirements, barring a major war. Their forecast indicates that by the end of 1967, cumulative crude-oil discoveries should reach 120 billion barrels, with proved reserves standing at 38 billion barrels—about 13 times the then current rate of production.

Where will it come from? . . . To this obvious question, the authors outlined the probable sources for all this new oil of the future 15 years. In eastern United States they look to Florida for a major share, with the old areas of New York, Pennsylvania, and West Virginia continuing their gradual decline.

In PAW District 2 covering principally the Mid-Continent, they predict an increase from the present 1,176,000 bbl. to 1,490,000 bbl. daily, principally from the Dakotas. They look to the Gulf Coast from Alabama to Texas, and including Arkansas and Louisiana (PAW District 3) for substantial increases in production; from 4,119,000 bbl. daily in 1951 to 5,720,000 bbl. per day in 1967. A 70 per cent increase in Louisiana production is in-

dicated, and Mississippi output should double. Offshore production in Texas is projected at about 68,000 bbl. per day by 1967. Substantial increases are expected along the Texas Gulf Coast, with similar gains for the prolific Permian basin of West Texas.

In the Rocky Mountain area (PAW District 4) they see the Montana portion of the Williston basin growing to about 180,000 bbl. per day and Wyoming's output expanding a little more than 100,000 bbl. per day. For the Pacific Coast they predict continuation of the present rate of production, with offshore gains offsetting the inshore decline.

Domestic demand . . . Turning to the demand side of the picture, Boatwright stated that their work is based on the broad assumption that present economic controls will be eliminated and that an industry free to make decisions on economic considerations will be re-established.

Altogether, several hundred indices of change were analyzed in plotting future demand. These included population growth, industrial production expansion, capital investment in new plants and durable equipment, the employment level, total energy needs and the shifting proportion of the total to be supplied by petroleum, transportation requirements, and agricultural and other off-the-highway gasoline and diesel oil needs.

Their demand curve rises to a total domestic figure of 10,280,000 bbl. per day by 1967, as compared with domestic demand for 7,043,000 bbl. per day in 1951. The expected decline in exports, to about 120,000 bbl. per day 15 years hence, will bring total demand of all products to 10,400,000 bbl. per day, a 39 per cent increase over 1951.

Gasoline demand will rise 46 per cent, they estimate. This would be higher were it not for an expected gain in the use of liquefied petroleum gas by trucks, tractors, and buses. The continued trend to dieselization and the emergent jet-fuel demand combine to give a 44 per cent increase in estimated demand of kerosine and distillate fuel by 1967. Shrinking residual fuel yields will be required by the continued shift to railroad diesels, which should see almost all oil-fired steam locomotives replaced by that date. Residual fuel demand will rise 20 per cent, the smallest gain of any product class.

The most significant increase forecast applies to "other products" which include lubricating oils, asphalts, waxes, petroleum chemicals, coke, still gas and liquefied petroleum gas. The latter, estimated for a 175 per cent gain, is largely responsible for the projected demand of 1,810,000 bbl. per day of "other products," as compared with 1951 demand for 943,000 bbl. daily.

Adequacy of supplies . . . Considering the projected availability of crude and natural-gas liquids in relation to the anticipated total demand for products, the authors predict that a 502,000-bbl. per day margin of domestic supply over total demand will be reached in 1967, compared with a margin of 300,000 bbl. per day in 1951.

Although this projected situation would show that purely domestic supplies will be adequate to meet total needs without imports, still affording the nation a protective cushion of about 5 per cent, the authors recognize that this comparison is unrealistic to the extent that there will be imports of both crude and products.

They proceed to measure total availability against total demand. By 1967, they see total estimated supplies of crude and natural-gas liquids from domestic production plus imports, as exceeding total demand including exports minus imports of finished products, by about 1,919,000 bbl. per day. That figure represents a more realistic estimate of the margin of total supply over total demand. The similar margin for 1951 was 1,161,000 bbl. per day.

Refinery expansion . . . To meet this continued demand, U. S. refiners will need to boost crude runs from the 1951 average of 6,494,000 bbl. per day to 8,763,000 bbl. per day by 1967.

On this basis, they predict that refinery capacity will reach about 10,700,000 bbl. per day by 1967, calling for an average annual expansion of some 250,000 bbl. per day. From the standpoint of basic capacity alone, this compares with refinery expansion at the average annual rate of 320,000 bbl. per day from 1946 through 1951.

Report on Evaporation

Groundwork for better conservation laid before A.P.I. in three-paper symposium on all phases of tank-loss problem

CHICAGO.—A long step toward improved conservation of petroleum and products was taken during a symposium at the American Petroleum Institute meeting here last week.

The session featured three papers concerning evaporation losses of petroleum from storage tanks. The papers were prepared under the supervision of a 12-member program committee headed by J. H. McClintock of Esso Standard Oil Co., New York.

This industry-wide committee representing production, refining, marketing, and transportation organized three groups, each instructed to collect the necessary data on a pertinent phase of the subject and to prepare a paper presenting the consensus of its views. The result is the most comprehensive survey ever undertaken on the subject, with special emphasis on practical information. *Texts of the three papers may be found on pages 266, 275, and 289 in this issue of the Journal.*

The first paper of the symposium was a review of the basic theory and mechanism and an outline of the practical problem of evaporation loss from petroleum in storage. From a definition of terminology and a thorough review of basic theory of vaporization, the paper proceeds to outline the scope of practical application.

An effort was made, said the authors, to translate theoretical considerations and observed experience into typical data of sufficient accuracy to permit valid evaluation of probable loss conditions for existing or new tankage. The theory on the subject was expressed in newly simplified mathematical expressions of volumetric flow through tank vents under temperature change and hydrocarbon content of tank vapors.

The review included a detailed analysis of the various events which occur in a typical 24-hour period in the life of an average oil tank, together with more comprehensive evaluations of the effects of the various pertinent factors such as temperature changes, vapor pressure, wind, vapor-space, volume, tank size and proportions, and time. The authors presented the prospect for establishing a simple and accurate "evaporation-loss formula."

New vapor-pressure charts . . . Of further practical value are a series of new vapor-pressure charts more accurate than those heretofore in general use. Recognizing the most recent research

on the subject, these charts differentiate between different grades of gasolines and crude oils. The data for crude oil are qualified as preliminary and subject to future addition and correction. In addition to the crude chart and the single chart for gasolines, the group included three vapor-pressure charts for gasoline in the R.v.p. ranges 2 to 6, 6 to 12, and 12 to 20 lb.

In order to clarify this and future studies on the subject, the first paper presents a recommended terminology for evaporation-loss work. An extensive bibliography also is appended.

The remaining two papers of the symposium deal specifically with evaporation loss from two classes of storage tanks: Cone-roof tanks which include all fixed-roof tanks with vents which have very low setting, and conservation-type tanks which include the floating-roof, low-pressure, and variable vapor-space types.

Cone-roof tanks . . . A working formula for determining breathing losses in fixed-roof tanks has not yet been developed because of a wide difference of opinion as to the relative value of each separate part of the theoretical formula.

The group concerned with the study of this type of tank reported that these differences could not yet be reconciled, lacking a sufficient number of tests isolating each factor so that its effect can be determined.

The group reports some progress, however, based on the many tests which have been made which measure the over-all breathing loss and record tank size, outage, Reid vapor pressure, and average temperature of the liquid body. These tests have been used directly or indirectly by many companies in developing methods for estimating breathing losses.

Eight such methods were compared, and an equation representing a composite of these methods was recommended. The paper also includes a chart which may be used to solve the equation.

Recognizing the need for further study of breathing loss, the group presents the equation as the best present approach to the problem until further refinements can be made.

For estimating filling loss, an equation is recommended as representing the loss of a volume of saturated vapor equal to the volume of liquid handled through the tank. A factor is used to account for a reduced degree of saturation when the frequency of tank turnovers is high. This equation also has a chart to be used in its solution.

Conservation-type tanks . . . Vapor-loss calculations undergo extensive study in the third paper of the symposium.

Intended to serve as the best guide available, the survey is not presented as the final word on loss estimation. Data on riveted floating-roof tanks are reasonably complete and accurate, but the authors note that similar data on most other tanks are not only insufficient, but are somewhat out of date and should be supplemented with current data on more recently erected tanks with the latest improvements.

With these qualifications, similar to those made for cone-roof tank-loss calculations, the members of the group have compiled and evaluated the methods for determining probable losses in tanks of various types.

"If, under stated conditions of operation, the losses from a conservation-type tank are known or can be predicted with reasonable accuracy, and if the losses from a cone-roof tank under similar conditions of operation are known in like manner, then it becomes possible to predict the annual saving which results from the use of conservation tankage. This represents a primary factor in determining the payout. The valuation of the payout would also require data on the cost of the tankage to be compared, tax structure, and company policies. All of these are matters to be determined by individual companies for particular situations. Particular decisions in favor of installing conservation equipment will, at times, be made on the basis of the less tangible operating advantages rather than the reduction of evaporation losses, the authors said. They warn that many variables are involved which affect accurate estimations.

Advances in Research

Project leaders report to the Institute on what is being done in fundamental petroleum research to aid industry

CHICAGO. — The scores of A.P.I. fundamental-research projects, little understood or appreciated outside technical circles, are building a firm base for future progress in all divisions of the industry. One research class alone, concerning composition, and properties, is making one of the nation's most complex raw materials also one of its best known.

The growing fund of data on what hydrocarbons comprise petroleum and what their properties are establishes the groundwork for continually improving its utilization. The program has further results, of equal importance. Not only data, but pure samples of petroleum fractions are being made available for academic, government, and industrial research. Many participants feel that the methods of separation, purification, synthesis, and analysis which have been developed in pursuing these research projects are of as great if not of greater value than the analytical results which have been obtained.

A significant point to all this basic research is the well organized manner in which the findings are reported, catalogued, and disseminated. Scientists here and abroad can obtain these data without delay, because of the application of practical, progressive methods for organizing the growing fund of knowledge on petroleum composition and properties.

Quarter-century of research . . . Special attention is currently due to the first of these research projects which has completed its first 25 years of work.

Known as Project 6 on the "Analysis, Purification, and Properties of Petroleum Hydrocarbons," the research effort is an outgrowth of an offer made to the A.P.I. by John D. Rockefeller, Sr., in 1925.

Expressing the opinion that the future welfare of the industry is to an important degree dependent upon an increased scientific interest in petroleum and its problems and possibilities, he contributed $50,000 a year for 5 years to such a program. The following year, Universal Oil Products Co. matched his offer and the project was begun in 1927. This project and many others like it have since been carried on with funds contributed by member companies of the A.P.I.

In their 1952 report on results of Project 6, Sherman S. Shaffer of Humble Oil & Refining Co., and Frederick D. Rossini of Carnegie Institute of Technology outlined an impressive research record.

"Starting with an extremely meager

ATTENDING THE FUNDAMENTAL Research Session of the A.P.I. and seated at the speakers' table were, left to right: Dr. Robert E. Wilson, Standard Oil Co. (Ind.), chairman of the board of directors of the Research Committee; Howard G. Vesper, California Research Corp., San Francisco; Harry Sutherland, Shell Oil Co., Modesto, Calif.; W. D. Seyfried, Humble Oil & Refining Co., Houston; W. G. Lovell, Ethyl Corp., Detroit; R. R. Brattain, Shell Development Co., Emeryville, Calif.; S. S. Shaffer, Humble, Baytown, Tex.; and W. E. Kuhn, The Texas Co., New York. Wilson presented certificates of appreciation, after which six project reports on research on composition and properties of petroleum were presented.

background of information and without laboratory equipment adequate for the task, the results of investigations by Project 6 during the quarter-century of its existence have made petroleum one of the best understood natural organic raw materials. In the boiling range up to 207° F. every possible member of the normal-paraffin, branched-paraffin, cyclopentane, cyclohexane, and benzene series has been identified and quantitatively estimated except for a few extremely rare hydrocarbons which are believed to be present in only very small amounts. In all, 130 hydrocarbons have been isolated from the large sample of typical Mid-Continent petroleum which was selected for this investigation."

The light shed on these petroleum components is but part of the story. Their separation and study have contributed to numerous improved techniques which have found research and commercial applications elsewhere.

Such methods include high-efficiency stills; adsorption, extraction and crystallization techniques; vapor-pressure, density, boiling-point, and freezing-point methods; and spectrometric inspection of the resulting fractions. This basic study, combined with the improved laboratory techniques which attended it, have provided invaluable information to research personnel in developing and evaluating conversion processes.

Superfuels . . . Important supplementary data have been provided in another A.P.I. research project (45) dealing with "The Synthesis, Purification, and Properties of Hydrocarbons of Low Molecular Weight," now in its fourteenth year.

Cecil E. Boord, of Ohio State University, and Wheeler G. Lovell, of Ethyl Corp., in their current report on the project outlined its three-point program. Total synthesis of whole groups and series of compounds, engine testing of these compounds, and superpurification of compounds for determining physical constants and for distribution to other research laboratories.

Their attention on engine testing of these pure hydrocarbons has given the industry new insight into the specific compounds which show "superfuel" characteristics. More important, the study is revealing more and more the relationships of structure, molecular weight, and saturation to energy output in modern engines. A new conception in blending values of certain hydrocarbons, which depart from clear properties, is resulting from this study, and blending studies, particularly, are marked for further attention.

Lube fraction studies . . . A companion study to the one noted above is Project 42 on "The Synthesis and Properties of High Molecular-weight Hydrocarbons."

Its objectives are to prepare pure hydrocarbons in the lubricating-oil range, to develop new synthesis and purification methods as necessary and to determine precise physical properties of such compounds.

Here again, the value of basic data on this molecular-weight class of hydrocarbons is attended by important findings which have been utilized directly in refining process design and calculations.

Future improvements in lubricating oil performance are not restricted to the field of additives, and it is to be expected that the work of this group will continue to contribute to the commercial production of better lube-oil base stocks through new knowledge permitting more proper selection and better processing.

Included in plans for future work are density and viscosity studies at high pressures, according to Robert W. Schiessler, Pennsylvania State College, and Harry Sutherland, of Shell Oil Co., Modesto, Calif.

Organization of data . . . A key project in the group on composition and properties of petroleum is No. 44, entitled "Data on Hydrocarbons and Related Compounds."

In reviewing the work on this project, Dr. Wayne E. Kuhn of The Texas Co. emphasized that it is highly probable that some of today's areas of ignorance would surely be areas of knowledge in the next decade because of Project 44's work.

The group has applied modern methods to the collecting, evaluating, and disseminating of data on the physical constants of hydrocarbons and related compounds. In order that the tables of data of the project might be of greatest usefulness to engineers and research organizations, the selected values of properties were converted into appropriate engineering units.

These physical and thermodynamic data comprising more than 100,000 entries, have been placed on I.B.M. punch cards. By means of this system, utilizing International Business Machines, any scientist desiring information on any problem within the scope of the project can be assured of a correct answer within minutes.

Oil Men Receive Industry Honors

CHICAGO.—Special awards in recognition of meritorious service to the petroleum industry were presented to 48 men here last week at the thirty-second annual meeting of the American Petroleum Institute.

The awards were for outstanding work done in the fields of transportation, research, safety, marketing, production, reserves, public relations, and governmental affairs.

They were presented at group sessions of the various departments of the Institute.

Of the 48, the Division of Production presented 17, the Division of Marketing 3, the Committee on Petroleum Reserves 2, the Division of Transportation 7, the Oil Industry Information Committee 10, and the American Petroleum Industries Committee 1. Four certificates of appreciation were presented for work in the field of safety, and the remaining four were for service in the field of research.

DIVISION OF TRANSPORTATION . . .

H. S. ELKINS
National Pet. Assn.

RESEARCH . . .

K. C. HEALD
Gulf Oil Corp.

C. V. MILLIKAN
Amerada Pet. Corp.

A. E. MILLER
Sinclair Refining Co.

W. M. SWEENEY
Standard Oil Dev. Co.

H. A. GILBERT
Oil Transfer Corp.

F. W. LITTELL
Shell Pipe Line Corp.

SAFETY . . .

R. T. HENDERSON
Standard Oil Co. (Ohio)

G. F. PRUSSING
Consultant

H. J. WILSON
Tide Water Assoc. Oil

B. A. MOELLER
General Pet. Corp.

C. R. MUSGRAVE
Phillips Petroleum Co.

M. E. NUTTILA
Cities Service Oil Co.

DIVISION OF MARKETING . . .

H. J. KENNEDY
Continental Oil Co.

E. J. McCLANAHAN
Standard Oil of Calif.

A. A. STAMBAUGH
Standard Oil Co. (Ohio)

A.P.I.C. . . .

J. J. COSGROVE
Continental Oil Co.

J. H. PEPER
Buckeye Pipe Line Co.

J. J. POWELSON
Esso Standard Oil Co.

DIVISION OF PRODUCTION

H. H. ANDERSON
Trans Mtn. Oil P. L. Co.

C. W. FROOME
Union Oil Co. of Calif.

H. M. HENDERSON
Standard Oil of Calif.

M. J. KIRWAN
Cities Service (ret.)

R. F. SHUMAKER
Sinclair P. L. Co. (ret.)

P. R. APPLEGATE
Buckeye Pipe Line Co.

F. E. BERNSEN
Lucey Products Corp.

C. FITZGERALD
Sinclair Pipe Line Co.

G. RAYMOND
Union Tank & Sup. Co.

M. SCHWARZ
Seaboard Oil Co. of Del.

J. C. ASKAM
Ohio Oil Co.

S. B. TERRY
Munitions Board

A. J. MORGAN
J. A. Roebling's Sons

L. A. OGDEN
Pure Oil Co.

J. J. SCHMIDT
East Ohio Gas Co.

F. J. SPANG
Spang & Co.

T. G. STITT
Pittsburgh Steel Co.

OIL INDUSTRY INFORMATION COMMITTEE . . .

G. D. McDANIEL
Soc.-Vac. Oil Co., Inc.

G. F. McMILLAN
Gulf Oil Corp.

H. E. MILTON
Milton Oil Co.

R. T. SEIDEL
Shell Oil Co.

E. L. STAUFFACHER
Cities Service Oil Co.

H. A. TROWER
Phillips Petroleum Co.

PETROLEUM RESERVES . . .

W. E. BLACK
Esso Standard Oil Co.

R. F. CAREY
Shell Oil Co.

M. FARNSWORTH
Gulf Oil Corp.

T. E. HORTON
The Texas Co.

F. H. LAHEE
Sun Oil Co.

J. M. SANDS
Phillips Pet. Co. (ret.)

Management Trends

Problems now so complex that big companies must keep on the alert to stay ahead; management training is gaining

CHICAGO. — Problems of management of a big company are becoming so complex that special means are required to deal with them.

Company policies must be reviewed constantly to be sure they are abreast of modern trends and are currently in the best interests of the company, speakers told the financial and accounting sessions during the annual A.P.I. meeting.

This division's program included a forecast that business activity will remain at a high level after a readjustment expected in about a year, a plea to make the oil industry even more competitive by resisting all attempts to foster so-called soft competition, and discussions of current trends in retirement pension plans and types of management organizations.

Making oil "fit" . . . The way to make the oil industry fit into the American way of life is to work constantly to keep it completely competitive, it was declared by A. A. Stambaugh, chairman of the board of Standard Oil Co. (Ohio).

The only thing of importance in the world is people, and the strongest driving force of the human race is the desire for individual expression, he said. Working against this is the bribe of security, and in this direction lies the totalitarian state.

Therefore, said Stambaugh, the oil industry should work against anything tending toward "soft" competition, such as the National Recovery Act or the Robinson-Patman Act, which provides security for the weak instead of making the weak strong, because "competition is the essence of democracy."

"During the 1920's," he said, "companies like my own carried the price umbrella over their more realistic competitors. In the 1930's the National Recovery Act performed the same function. But in the 1940's there apparently was no one willing to carry this torch. I submit that this was a fortunate thing for all of us."

Price uniformity, market leadership, and other attempts to soften competition will not work very long and in the meantime lead to uneconomic practices which ultimately cost consumers and the industry tremendous sums, Stambaugh said. He gave credit to small operators for keeping competition keen and for being more realistic in their pricing policies.

Trend in management . . . The biggest job of the modern corporation president is to contend with the lobbyists in his own organization, the financial and accounting session was told by T. F. Bradshaw, management expert of the firm of Cresap, McCormick & Paget, New York.

By this he meant that the sales manager, research director, production manager, and all other department heads see problems only from one angle and argue strongly for their point of views, no one of which is necessarily the best for the company.

Instead of letting conflicting views cancel each other out or letting the decision go to the most persuasive talker, Bradshaw said there is developing a new management technique in many corporations because of the realization that the president's job is too big for any one man.

One phase of this, particularly prominent in the oil industry, is the concept of a planned management development, through which junior executives are deliberately and gradually trained for positions of over-all management.

Some companies are using a staff group known as a control section reporting directly to the president, while others work through a new official called a financial executive. Regardless of what form of organization is used, Bradshaw said, it is essential to recognize that coordinated planning and keeping actions in conformity with company policy is a function distinct and different from those of research, selling, or production operations.

Business Downturn

Nadler sees one in a year or two, but not a bad one

CHICAGO.—There will be a downward readjustment in business activity some time in 1953 or perhaps in 1954, but it is not likely to be very serious in character nor last very long, in the opinion of Dr. Marcus Nadler, professor of finance at New York University.

In the meantime, he said, the present high level of activity will be maintained for several months. The momentum is so great that practically nothing can stop it, military and capital expenditures will be large, the disposable income in the hands of consumers is increasing, employment is plentiful, wages are high, and the soft-goods industries have overcome the period of readjustment and are increasing output and sales.

The sellers' market, Nadler warned, is rapidly coming to an end and, before many months are over, the buyers' market will reassert itself with full force in all lines. Business will be more keenly competitive than it has been for a great many years.

Basis for prediction . . . Nadler's prediction that the readjustment accompanying the full transition to a buyers' market will not be serious was based on these considerations:

. . . The economy of the country is dynamic, with population and living standards increasing, new inventions, and business and individuals in a sound financial position.

. . . Geographic shifts in population and decentralization of cities create demands for new homes, utilities, and other facilities.

. . . The position of credit and capital is sound, with no chance of widespread bankruptcies, bank failures, and foreclosures, and speculation with bank credit is at a minimum.

. . . Business draws new capital much more from institutional investors than from individual savings, and the supply of capital is therefore less volatile.

. . . Obsolescence is a much more important factor than in the past, because high labor costs will compel huge new investment in more efficient equipment.

. . . Pensions, unemployment insurance, and other social changes of the past 20 years will have a profound effect in maintaining individual purchasing power.

"One can look forward to the future with confidence," Nadler said. "This, however, does not imply that business activity will continue on a straight line upward. A dynamic economy is bound to be marked by ups and downs. However, unless something unforeseen should occur, the 'downs' will not be very pronounced, nor will the period of readjustment last very long."

The greatest problem facing the oil industry in the future is the international situation, Nadler declared, and some way must be found to permit foreign countries to pay their debts and continue to buy from the United States without flooding this country with excessive imports.

Demand to Level Off

Rate of increase is down from what it was, Brown tells marketing men; Moreell sees internal threat to security

CHICAGO.—Stressing a development which was widely discussed in other quarters at the annual A.P.I. meeting, Dr. Courtney C. Brown, a director of the Esso Standard Oil Co., New York, told an oil marketing session that some leveling off in petroleum demand is in prospect.

Explaining that he was not attempting a definite forecast for the future, Brown pointed to reduced increases in demand over the past several months as indicating that the peak in postwar expansion is past.

He said that domestic oil demand during the past 9 months has averaged about 3 per cent greater than the same period in 1951, which contrasts with the 6 to 8 per cent gains to which the industry had become accustomed over a large part of the postwar period. He said that a comparable situation has developed in foreign markets.

Indicative of the producing capacity of the world oil industry, Brown pointed to the fact that within a period of about 18 months operators were able to offset the loss of Iranian production and effects of a labor strike last spring affecting a substantial part of the refining industry in this country. "It is probably reasonable," he said, "to say that the present situation would not be as firm as it is if these two events had not occurred."

Lower output expected . . . Relative to operations next spring, a matter of concern to some of the industry's economists, Brown said it is estimated that next summer's domestic petroleum demands may be 800,000 bbl. daily less than they will be this winter.

It was indicated that this would necessitate a lower level of operations in both crude-oil production and refinery operations after the winter needs had been taken care of despite the seasonal necessity of accumulating stocks of distillates and other fuels for the 1953-1954 winter season.

Brown also said in his analysis that consumption of oil products is becoming more sensitive to changes in general business conditions. Regarding general business Brown said, "There is enough evidence accumulating to justify a note of caution about the general business outlook."

The oil business can cope with these changed conditions applying to demand and supply, Brown said. "There may be some ups and downs in the road ahead, but it need not be too rough a road as long as this great industry remains free to select its own road, and as long as it continues to exercise the same kind of foresight and courage that has come to be identified with it over the years."

Domestic dangers . . . While we are spending huge sums to combat communism in other countries, including the support of military forces, we are so conducting our affairs at home that we are in danger of losing the battle against communism here at home, Adm. Ben Moreell told the marketing group.

"We are concentrating on fighting communism many thousands of miles away," Moreell said, "but, when we look at the record, we are forced to wonder whether we Americans may not be choosing the wrong battlefield at the wrong time against the wrong enemy. It may be that, while we are fighting Communist armies, communism itself is marching steadily forward under the stimulus of easy triumphs here at home."

Moreell, who had one of the outstanding military records of World War II, said the dangers at home include:

1. Expansion of public ownership of land.

2. A heavy progressive or graduated income tax.

3. Abolition of all right of inheritance.

4. Confiscation of the property of all emigrants and rebels.

5. Centralization of credit in the hands of the state by means of a national bank with state capital and an exclusive monopoly.

6. Centralization of the means of communication and transport in the hands of the state.

7. Extension of state-owned factories and instruments of production.

8. Equal liability of all to labor. Establishment of industrial armies, especially for agriculture.

9. Combination of agriculture with manufacturing industries; gradual abolition of the distinction between town and country by a more equable distribution of the population over the country.

10. Free education for all children in the public schools. Combining education with industrial production.

These measures, Moreell said, are the battle plan of communism. These basic goals were formulated by Marx and Engel 100 years ago. This same strategy is pursued today by the Communists.

Stressing the fact that majority approval of an action of Government does not make it right when it conflicts with the principles on which this country was established, Moreell concluded with a strong plea for the acceptance of individual responsibility as the basis for individual freedom.

Jobbers need convincing . . . That some independent jobbers are still suspicious and fearful of the large integrated companies which supply the products they sell was apparent from the talk of Otis H. Ellis, general counsel of the National Oil Jobbers Council, Washington, D. C., to the marketing group.

The jobber head said that this attitude toward his large supplier has brought a feeling of instability which colors his thinking and actions in other matters, including the need for cooperation of these independents in programs which seek to strengthen the position of the entire oil industry. He said it is the duty of the integrated oil companies to so conduct their activities with jobbers and dealers that these fears will end and they can all join together in combating the evils of big government. He said he hoped to see the day when every dealer would be a defender of the petroleum industry.

Ellis said that this mutual understanding between the large and small units of the oil industry is necessary in combating a labor situation brought about by a "robot maneuvered by labor leaders with the sanctions of the federal Government."

Jobber study approved . . . Following a talk by Samuel Rosenwasser of the Gas Merchants of Brooklyn, marketers, in the final session of the annual meeting, the Marketing Division authorized the appointment of a committee which will make studies of what is needed to bring about improved relations between suppliers and dealers.

This has long been an objective of representative dealers and jobbers and refiners. Appointment of the committee is the first time that a solution to this problem has become one of the objectives of the A.P.I. marketing division.

The study, which received the approval of several speakers, will seek to secure the cooperation of more than

TYPICAL OF THE 127 committee meetings which were held as early as 4 days prior to the opening of the annual A.P.I. meeting was this group, the Nondivisional Committee on Liquefied Petroleum Gas. Only about half the members in attendance are shown here. Left to right are, seated, H. E. McAuliffe, Jr., Socony-Vacuum Oil Co., Inc., New York; Joe Miller, Humble Oil & Refining Co., Houston; I. E. Killian, Esso Standard Oil Co., New York; Arthur Delau, United Petroleum Gas Co., Minneapolis; Joe Lyons, United Petroleum Gas Co., Houston; P. C. Jurs, Shand & Jurs, Berkeley, Calif.; E. E. Kerns, Standard Oil Co. (Ohio), Cleveland. Standing are: George R. Benz, Phillips Petroleum Co., Bartlesville, Okla., committee chairman; E. O. Mattocks, A.P.I., New York; A. J. Rumoshosky, A.P.I.C., New York; J. Y. Haslam, Skelly Oil Co., Tulsa; W. F. Lowe, Natural Gasoline Association of America, Tulsa; Rex V. Phelps, Warren Petroleum Corp., Tulsa; E. H. Barlow, Standard Oil Development Co., New York; E. F. Voss, Humble, Houston; M. L. Arnold, Richfield Oil Corp., Los Angeles; R. K. Schulze, Shell Oil Co., New York; and G. W. Sanders and Paul Bond, Pure Oil Co., Chicago. Not shown is a large group seated at a table out of the picture at left.

200,000 domestic dealers as an integral part of the oil industry.

The importance of this large group, termed the "firing line of the oil industry in its relations with the public," was stressed in connection with the oil industry's public-relations program and also the many problems that arise from time to time in wholesale and retail marketing. One speaker said that the retailers have 60 per cent of the contacts of the oil industry with the public. Because of misunderstandings, part of the group have often been antagonistic toward programs which have been sponsored by refiners and jobbers.

Lubrication report . . . Reports by the lubricating committee of the marketing division revealed that there had been steady progress in the acceptance by the automotive and oil industries of the new lubricating oil classifications approved by A.P.I. last year.

It was stated that General Motors Corp. will adopt the classifications in the owners' manual for 1953 cars, and other manufacturers are expected to take similar action in the near future. Sixteen oil companies are using the classifications in their packaging departments.

How to Get Along With Government

CHICAGO.—The basic solution to unsatisfactory relations between Government and industry is for businessmen to concern themselves with the problems of Government, H. S. M. Burns, president of the Shell Oil Co., told those attending a general A.P.I. session sponsored by the American Petroleum Industries Committee.

"The only worthwhile interest in Government is a constructive interest," Burns said.

"Every American businessman might well adopt this motto: 'We have no right to complain about an idea that comes from Government unless we are willing to take trouble to work out a better idea.' Why should our attitude toward Government be any different from our attitude toward our products? After all, Government is the product of all of us."

The head of the Shell interests in this country pointed that such businessmen as Alexander Hamilton and Benjamin Franklin had concerned themselves with the problems of Government in its early days with satisfactory results both for Government and for business.

Data were presented by Burns showing the dominant position that petroleum now has in the economic life of this country. Business, he said, must "build a healthy climate of public thinking for the future and we must fight the running day-to-day battles for our freedom to serve without undue restrictions and for needlessly burdensome taxes."

Twentieth anniversary . . . Cyrus S. Gentry, chairman of A.P.I.C. and vice president and general counsel of the Shell Oil Co., presided at the meeting which marked the twentieth anniversary of the committee.

The organization devotes its activities primarily to legislative tax matters. Special attention has always been given to the state gasoline taxes and related matters and the committee is given credit for the fact that the gasoline tax rates have not gotten out of hand, a threatening development at the time the organization was formed in 1932.

COMMITTEE MEMBERS of the public-relations committee of the A.P.I. board of directors. Clockwise from the left foreground are: B. L. Majewski, Great American Oil Co., Chicago; S. A. Swensrud, Gulf Oil Corp., Pittsburgh; R. G. Follis, Standard Oil Co. of California; J. N. Pew, Sun Oil Co., Philadelphia; E. L. Shea, Ethyl Corp., New York; K. S. Adams, Phillips Oil Co., Bartlesville, and Jake L. Hamon, Dallas.

Outlook is Improving

Surveys show O.I.I.C. is moving ahead in gaining public understanding of oil; Esmay reports on successful year

CHICAGO.—The oil industry's public-relations program will be widened and intensified during the coming year with continued emphasis on the direct relationships of jobbers and dealers with the many millions of petroleum consumers.

The Oil Industry Information Committee (O.I.I.C.), which for 6 years has been in charge of this program, gave an account of its stewardship at the annual A.P.I. meeting here reflecting greater activity than any previous period. The A.P.I. directors approved the 1953 budget which had previously been adopted by the O.I.I.C. steering committee.

The 1953 budget was set at approximately three million dollars, an expenditure which includes the maintenance of the headquarters in New York City, an expanded field force operating from 11 field offices scattered throughout the country, national advertising, and the hundreds of other activities necessary to tell consumers about the oil business.

C. Z. Hardwick, vice president of Ohio Oil Co., who has served as chairman of O.I.I.C. over the past year, presided at the general A.P.I. meeting devoted to public relations. The principal report covering the accomplishments of the past year was made by E. W. Esmay, who has served as director during the military leave of Adm. H. B. Miller.

Cooperation expected . . . For the first time O.I.I.C. during the coming year will be headed by a jobber—Stanton L. Smith, president of Smith Oil & Refining Co., Rockford, Ill.

Smith is widely known in marketing circles and it is felt that his direction as chairman will be helpful in securing the general cooperation of jobbers and dealers in making O.I.I.C. plans effective for the coming year. It is admitted that the jobber-dealer participation has not been as general in the past as has that of other segments of the oil industry.

Figures presented here showed that the cooperation of oil men in carrying out the community "grass roots" phases of the oil industry's public-relations planning is increasing. It is felt by many that activity which is largely dependent on oil men, themselves, becoming more public-relations conscious is of more importance than any other division of the program.

Over the past year 3,295 of these organizational meetings were held with a total attendance by oil men of 50,500. Volunteer committees at the local level have numbered more than 20,000.

What's been done . . . Reports made to O.I.I.C. headquarters showed that 7,227 speeches have been made so far this year with 752,000 oil consumers in attendance.

The greatest public interest has been in the specially prepared movies depicting operations and services of the oil industry and 13,780 showings this year were attended by 1,937,000 people. Included in this total were 195,113 agricultural students in the southeastern states.

Other publicity directed by the field and headquarters offices included 441 television programs and more than 3,000 radio broadcasts. A large number of exhibits concerned with oil industry have been shown at fairs and similar events.

Oil Progress Week last month was said to have been the most successful since this yearly event was made an important part of the O.I.I.C. program. It was pointed out that the longer this special week is stressed the greater will be the public participation. Attention was called to the fact that women's organizations, within and outside the oil industry, are more and more interested in the objectives of Oil Progress Week.

Checks made from time to time at the direction of O.I.I.C. reveal that the oil industry is making progress in its main objective of bringing about a better understanding of the problems and accomplishments of the oil industry by its customers.

It was a nation-wide survey made by a well-known research organization several years ago that brought about the decision to start a public-relations program. The checks show that a great deal is yet to be done everywhere along educational lines involving marketing practices, and prices and other matters having to do with the competitive position of individual companies.

Behavior is important . . . The basis for success in the oil industry's public relations is "to think like oil men, to act like people" H. S. M. Burns, president of Shell Oil Co., told the O.I.I.C.-sponsored meeting in the concluding address of the session which was attended by several hundred oil men representing all divisions of the oil industry.

Burns, who is chairman of the A.P.I. public-relations committee from the board of directors, emphasized that success in public relations will in the final analysis depend on how the industry and individuals who compose it conduct themselves.

"Public relations is everybody's job and no amount of advertising or public speaking will cover up the wrong kind of behavior," Burns declared. "If we offend the public by our actions we cannot avert its displeasure by words. There is no quick panacea that will accomplish our objectives by one quick shot in the arm."

Simplicity, Burns said, is probably the most vital factor involved in telling the industry's story to the general public.

Synthetics Appraised

Unusual characteristics of certain synthetic oils make them desirable for special lube functions, S.A.E. told

John C. Reidel

TULSA.—Development of an excellent universal winter-grade crankcase oil is possible through the use of polypropylene glycol synthetic oils.

In a paper presented at the national Society of Automotive Engineers fuels and lubricants meeting held here November 6-7, J. A. Miller and H. F. Galindo, California Research Corp., Richmond, Calif., said these new synthetics, made by polymerizing propylene oxide, provide easy starting at low atmospheric temperatures and perform well at normal engine-operating temperatures.

Propylene glycol oils, the authors said, are obtained as a series of high-viscosity-index oils over a wide range of viscosities. Low volatility is a characteristic. In the low-viscosity range, the oils also are miscible with mineral oils. "This oil miscibility," they said, "permits the use of these synthetics as blending agents for low-temperature conventional oils while retaining most of the excellent physical properties of the synthetics. In addition these blends can be effectively compounded with conventional additives."

Unusual property . . . The synthetics have the unusual property of forming volatile products on oxidation rather than high-molecular-weight polymers or sludges formed by conventional mineral oils. To obtain good consumption characteristics, the synthetics must be properly inhibited.

Synthetic oil in the 5W grade has performed well in Alaska and the colder areas of Canada and the United States. This type of oil could be used, the authors said, even in milder climates to give quicker starts in winter, afford relief to the battery, and obtain improved fuel mileage through the use of a lighter oil. Blends of mineral oil with synthetic oil and the proper conventional additives can be provided to cover current service requirements of diesel engines.

Synthetic specialties . . . Engineering possibilities of special synthetic lubricants, both oils and greases, were discussed by W. A. Zisman, Naval Research Laboratory, Washington, D. C.

These include aliphatic esters, polyalkylene esters, the silicones, esters of phosphoric and silicic acids, and the highly fluorine-substituted hydrocarbons. They are used for turbojet-engine lubrication, for aviation instruments, and aircraft machine guns and automatic cannon.

Possible future use of these synthetics is foreseen for more commonplace mechanisms such as electric motors and sewing machines.

The performance of ester-type turbo-engine synthetic oils was discussed by A. B. Crampton, W. W. Gleason, W. E. Lifson, and E. F. H. Pennekamp of the Standard Oil Development Co., Linden, N. J.

With regard to availability of these oils in time of emergency, it was noted that: "the ester-type oils based on chemicals derived from petroleum are potentially widely available and lower in cost than those derived from other sources. It is believed that these petroleum-source synthetic products will eventually be the most widely used type."

Engine deposits . . . If engine deposits could be eliminated, compression ratios could be increased a full unit and gasoline octane numbers reduced substantially, according to H. J. Gibson, C. A. Hall, and D. A. Hirschler, all of Ethyl Corp.

Engine deposits form more rapidly in city traffic than in open-country driving, experiments have shown, and are more severe in passenger cars than in trucks.

Organic materials formed from both the fuel and the oil are of major importance in formation of combustion-chamber deposits. The volatility of oil and fuel are more important than the carbon-hydrogen ratio. However, engine operating conditions and engine design also have a major influence on formation of deposits, the authors said.

Geophysical Challenge

Skyrocketing expenditures on geophysics mean industry must attract and hold better-trained men, S.E.G. told

Philip C. Ingalls

FORT WORTH.—During 1951 the oil industry of the United States spent more than $300,000,000 on geophysical operations—and an even larger investment is anticipated this year.

Using these large sums as recognition of the value of exploration geophysics, W. Dow Hamm told more than 1,000 oil-exploration scientists gathered here for the midwestern meeting of the Society of Exploration Geophysicists that a tremendous responsibility has been imposed on the geophysical industry.

Hamm, general manager of exploration for Atlantic Refining Co., Dallas, said that in order to meet the challenge of this responsibility geophysics must provide incentives to attract and hold better-trained men. To provide these incentives, he said, the oil industry must have the advantage of a free competitive system in which to grow.

Must get them back . . . Recognizing the need for earth scientists in the Armed Forces as well as in civilian occupations, Hamm pointed out that the number of trained men in this field is too small to permit diversion of any to military duty which does not call for full use of their scientific training. He said that this country's defense effort demands more efficient use of trained earth scientists.

Hamm said that because no new exploration tools are in prospect, exploration men must make better use of their existing tools—that there must be continued coordination and cooperation between geologists and geophysicists.

"There is a need for geologists to become better geophysicists and for geophysicists to become better geologists," he said, adding that as long as there is teamwork there will be no need to worry over the supply of oil and other minerals in the foreseeable future.

Active area . . . The Permian basin of West Texas and New Mexico now has 45,000 wells producing approximately 1,300,000 bbl. of oil daily—greater than the combined production of Louisiana and Oklahoma—H. L. Swords, Union Oil Co., Midland, Tex., said.

Swords, in his paper on "Explora-

tory Activity in the Permian Basin," said that while the number of seismic crews in the United States has tripled during the past 10 years, seismic activity in the Permian basin has increased five times. He said that out of the 600-odd seismic crews in the country today, 120 of them are operating in West Texas and Southeast New Mexico.

Swords said that the peak for the area came in May of this year when 135 crews were operating.

He added that as a result of a forthcoming University of Texas land sale, Andrews County leads West Texas in seismic activity with 12 or 14 crews, all working in a small portion of the northeastern part of the county. The reef country of Kent, Scurry, Borden, and Howard counties, Swords said, has definitely passed its peak in seismic activity. Only one crew is now operating in the area. However, he added, six crews are working in another reef area which runs through Tom Green, Schleicher, and Sutton counties.

The high percentage of seismic success in southeastern New Mexico, particularly in northern Lea County, accounts for much of the increased geophysical activity in the Permian basin, according to Swords. He said that since the discovery of Crossroads field in 1948 almost half of the pre-Permian wildcats in northern Lea County have resulted in discoveries.

New Seismic Area

Southeastern states using techniques of West Texas

FORT WORTH. — Thorough testing of the seismic method in Alabama, Georgia, and North Florida is just beginning, according to Robert Baum, Seismograph Service Corp., Shreveport, La.

Addressing the midwestern meeting of the Society of Exploration Geophysicists, Baum said that 1952 will be a record year for seismic work in the southeastern states. He said that the reason the seismograph has not been used extensively in this area until recently probably lies in its past failure to provide satisfactory and consistent reflection records.

Baum said that while much is still to be desired in this respect, substantial improvement in instrumentation, field procedures, and interpretive techniques has been achieved in certain areas by operations of production and research crews.

Baum pointed out that the three fields in Alabama and the one field in Florida are structural traps of the type commonly sought by the reflection seismograph.

Zone of interest . . . At the present time, Baum said, principal exploration interests appears centered in the lower part of the Upper Cretaceous beds, a zone which is a rich producer of oil in East Texas and North Louisiana. Using cut-up map overlays, Baum illustrated that the size of the area comprising the southeastern states compares favorably with the size of the State of Texas and said the comparison implies large undeveloped areas exist throughout Alabama, Georgia, and Florida.

Baum said that much of the difficulty in obtaining good-quality reflection data is attributed to near-surface conditions such as the presence of the Citronella formation which blankets much of southern Alabama and northwestern Florida. He added that seismic reception is also affected adversely by erratic changes in weathering and elevation in many instances.

Baum reported that the success of future seismic efforts is believed to depend on continued experimentation concerning the influence of mantle rock and other near-surface effects. He said that some success has been reported with the use of the West Texas technique of multiple geophone and multiple shot-hole patterns.

Industry Briefs

NEW YORK.—A new Exposition of Basic Materials for Industry will hold its initial show at Grand Central Palace June 15-19, 1953. Planned as a clearing house for new products, industrial methods, laboratory developments, and new uses of old materials the exposition will cut across industry lines, according to Clapp & Poliak, Inc., of New York, managers.

CLEVELAND.—The American Society of Mechanical Engineers and the Society for the Advancement of Management will jointly sponsor the Plant Maintenance Conference to be held here January 19-22, 1953. The conference will include 66 separate sessions, panels, conferences and roundtables.

ENLARGED exposition grounds. Light areas are new.

I.P.E. Expanding

New exhibition area added as show sells out all space

TULSA.—All exhibit space has been sold out in the original plant of the International Petroleum Exposition and in the newest section acquired last summer.

However, a new north addition providing more than 4 acres of exhibit area is being opened to accommodate space demands, William B. Way, exposition general manager, announced last week.

"This second new section will enable us to set up more than 100 sheltered booths as well as additional 'outside' space," Way said.

The new area is a long strip on the north side of the existing I.P.E. grounds. The section at the top of the drawing above is reclaimed land added to the site earlier this year.

Comparing the forthcoming exposition to the last show held in Tulsa in 1948, Way said, "We have already written 652 contracts for this show and we expect to issue more than 150 additional contracts in the new north area.

"At the last show, we issued 526 contracts to exhibitors. About 98 per cent of them will exhibit again in 1953, as well as a number of new firms which will be exhibiting for the first time."

Subpoenas Limited

Court restricts types of material companies must submit in grand jury investigation of FTC's cartel accusations

Bertram F. Linz

WASHINGTON.—Companies involved in the Government's cartel investigation won a partial victory last week in the Federal District Court.

Ending argument on the companies' motion to quash or limit the subpoenas for the submission of their records, Judge James R. Kirkland, who previously had cut the period for which papers had to be submitted from January 1, 1928, to January 1, 1941, curbed the type and number of documents the companies are to produce.

Judge Kirkland did not rule on the sensitive issue of documents which the companies' attorneys said foreign governments would not willingly release, but gave the companies until December 8 to show that other governments object to the disclosure of contracts and other vital records.

The ruling . . . The scope of the subpoenas was cut down to papers relative to sales or purchases of production outside the United States involving 1,000,000 bbl. or more, and Judge Kirkland ruled that no papers on the financing of foreign refinery operations need be submitted and that records on the negotiation of contracts and other agreements be limited to those on the "executive level."

With respect to the documents which the companies contended would not be released by foreign governments, the judge ruled that they must show they made an effort in good faith to secure their release and were denied, and also must show the interest of a foreign government in any corporation or operation and furnish proof of foreign laws which may limit the production of the documents.

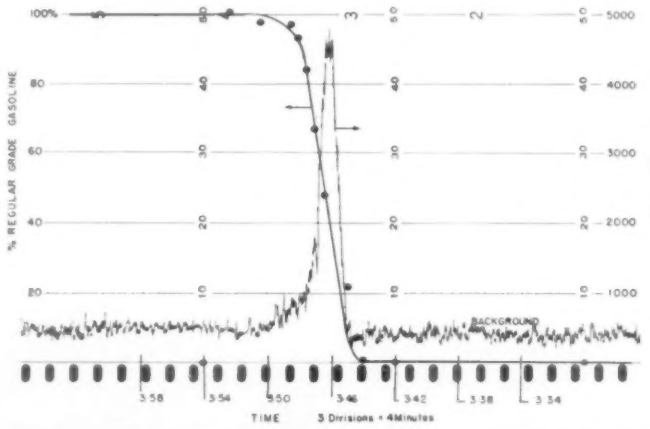
In giving the companies 4 weeks in which to make their showing, lacking which, he said, no action will be taken with respect to these documents, Judge Kirkland extended the return date of the subpoenas to January 12.

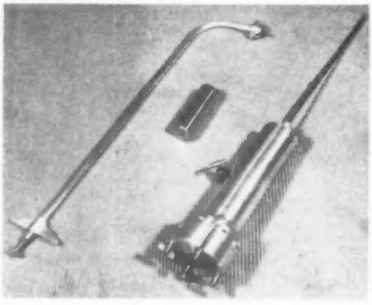
Supreme Court opens . . . The Supreme Court, meanwhile, resumed sessions after its month-end recess, but failed to announce whether it would accept the petition filed by the companies for review of early decisions.

Judge Kirkland admitted the possibilities of dangerous international complications in the release of sensitive documents, and at one time suggested meeting with foreign diplomats to hear their objections to the disclosure of such papers.

Leonard J. Emmerglick, special assistant to the attorney general, however, said the Department of Justice has set up machinery for the foreign governments to contact the State Department, which then would make representations to a group composed of representatives of the Justice, State, and Defense Departments and the Central Intelligence Agency.

First concrete evidence of the opposition of foreign governments to dis-





Radioactive Tracers Mark the Spot

RELATIVELY new in the pipe-line field are radioactive tracers which locate the interface between two tenders of products.

With present equipment, an operator can get a graph like that above which shows the exact center of the interface and permits switching at any desired point. At lower left is the injector used for admitting the radioactive solution into the pipe-line fluid.

The solution is forced from the capsule (center) through the injector (at right), which is connected into the pipe line by a gate valve. The lower right photo shows a field installation with a radioactivity detector which makes a record like the graph above.

The graph shown here shows the approach of an interface to a pipeline station. There is a low level of response before arrival of the interface due to background radiation. As it reaches the detecting unit, the level of radioactivity increases suddenly some 1,300 per cent. Immediately after passage, the level drops to its former value.

closures of their dealings with the companies came with the presentation by a representative of the Anglo-Iranian Oil Co. of a letter from the British Ministry of Fuel and Power stating the company could not provide wholesale documents without authorization of the British Government, since such disclosure might be prejudicial and could endanger the economy strategy of political interests of the government and the western powers.

Contract Approved

Government favors U.S. Pipe Line's plan

WASHINGTON. — The Department of Justice has informed United States Pipe Line Co. that it has no present objection to the "guaranteed tender contract" which the company proposes to offer on its projected products line from Beaumont, Tex., to Newark, N. J.

The net effect of the department's opinion is to assure the company the Government would not institute criminal proceedings under the antitrust laws in respect to the use of the contract and the provisions of the proposed tariff which will relate to it.

No assurance is given, however, against the institution at any time of civil proceedings to test the legality of the program or against civil or criminal proceedings "against any participants in the submitted plan if the plan in actual operation involves any agreement, arrangement, or practice not presented as part of the submissions in this matter."

The department also emphasized it expressed no view and took no position with respect to the plan in relation to the Interstate Commerce Act, the Elkins Act, or any other federal laws.

Requested by company . . . The department's views were requested by the company with respect to its plans to make the line available to all potential shippers, who will be offered guaranteed tender contracts for a maximum of 250,000 bbl. daily of products in the line as a whole, with at least 50,000-bbl.-daily capacity available for spot shipments in excess of contract movements. No single contract will provide for transportation of more than 50,000 bbl. The minimum tender would be not more than 30,000 bbl.

The company proposes to limit its contract operations to 5 years, at the end of which time all contracts will terminate and all shipments thereafter will be on a spot basis.

WATCHING WASHINGTON

Bertram F. Linz

Not So Much Less Steel

The oil and gas industry had less steel available last year than in 1950 but a lot more than it got in 1949.

Figures worked out by the American Iron and Steel Institute of the tonnage delivered directly to the industry in 1951 show it was nearly 153,000 tons less than in 1950 but close to 712,000 tons more than in 1949. The totals of shipments to oil and gas warehouses and distributors and for oil and gas construction and maintenance were 5,190,154 tons in 1951 against 5,342,984 tons in 1950 and 4,478,161 tons in 1949.

While shipments to warehouses and for construction were less in 1951 than in 1950, the reverse was true in shipments for drilling which rose to 834,632 tons from 620,444 tons in 1950 and 600,205 tons in 1949.

Old Attacks Never Die

There's a definite possibility that the Government's cartel attack on the oil industry may be dropped when the new Republican administration comes into office next year.

Whoever heads the State Department under President Eisenhower is going to find that the Federal Trade Commission report and the Justice Department investigation already have seriously damaged our standing abroad. Several foreign governments have made plain their resentment over the department's demand for records which they claim will reveal secret and hitherto suppressed details of governmental oil policies. Our own military authorities appear apprehensive that important information may be made available to Russia.

Since the grand jury investigation now cannot get under way before January 12 at the earliest and will have only a few days before the change-over in administration, the investigation could be dropped without much additional damage, and any illegal activities of the oil companies could be dealt with adequately without staging a three-ring circus.

Tax Slash in the Works

Tax revision definitely appears to be on the Republican legislative program for next year.

One of Gen. Eisenhower's strong campaign talking points was economy and tax reduction. Neither can be achieved overnight, but a start on both can be made immediately.

The new Congress, sometime before the end of the fiscal year, is expected to advance the termination date of the last increase in income-tax rates from December 31 to June 30. At the same time, it will permit the excess-profits tax to expire on its present statutory termination date June 30. In this way, Eisenhower can make a token installment on his promise to reduce taxes.

General overhauling of the present tax laws, however, is not expected to start until after the beginning of the new fiscal year next July 1. This will give the new administration time to see what economies can be made in the government and arrive at an over-all amount by which taxes can be reduced.

President Truman's final budget, for fiscal 1954, is reported to total about $70 billion, a reduction of about $9 billion.

Standby Controls Unlikely

Reports already are filtering in to Washington on what the Republicans will do next year.

Those reports indicate that, if the Defense Production Act is permitted to expire, there will be no legislation for standby controls as suggested by present mobilization officials.

The most that could be expected in that event would be continuation of a priorities system for the distribution of certain much-needed materials, including tubular goods for the oil and gas industry.

The standby controls recommended in the present administration could be invoked in the event of an emergency without action by Congress.

Industry spokesmen already have indicated they would vigorously oppose such authority, as opposed to our traditional avoidance of the grant of emergency powers for which no immediate need exists.

Members of Congress say it would not pass any such legislation unless it remained in control and had the say when regulation should be imposed. That would nullify the expressed objective on which the whole idea is based—speed of application.

A.C.S. LEADERS at the sixth annual trisectional meeting in Tulsa last week included, left to right, P. F. Cardwell, Dowell Incorporated, Tulsa; Clyve Allen, Anderson-Prichard Oil Corp., Oklahoma City, chairman of the Oklahoma section; W. Herschel Hopson, Stanolind Oil & Gas Co., Tulsa, chairman of the Tulsa section; Edgar C. Britton, Dow Chemical Co., Midland, Mich., national A.C.S. president; R. W. Blue, Phillips Petroleum Co., Bartlesville, chairman of the northeast Oklahoma section; L. F. Audrieth, University of Illinois, Urbana, Ill.; and H. M. Smith, U. S. Bureau of Mines, Bartlesville.

Petrochem Forecast

Dirksen tells chemists output will exceed 17 billion pounds this year, will be four times that in 10 years

Joseph A. Kornfeld

TULSA. — Petrochemical production in the United States is expected to exceed 17 billion pounds this year, A. J. Dirksen, Phillips Petroleum Co., Bartlesville, Okla., told an American Chemical Society meeting here last week.

Addressing the sixth annual tri-sectional meeting of Oklahoma chapters, Dirksen said that petrochemicals accounted last year for more than 70 per cent of all organic chemical production, compared with 28 per cent in 1946; this production includes carbon black, sulfur, and ammonia, but excludes synthetic rubber.

Dirksen, assistant manager of the market-development division of Phillips, predicted "a practically unlimited future" for petrochemical production. He estimated 1962 requirements at 64 billion pounds, or about four times present production. However, 1962 needs of petroleum raw materials will not exceed 1 per cent of the total United States petroleum production in that year, he said.

Capital investment in petrochemical plants rose from 350 million dollars in 1940 to 1.95 billion dollars in 1951, he said, adding that by 1975 this investment should exceed 5.2 billion dollars. Fifty of the existing 130 plants in the United States are located in the Gulf Coast region.

Sulfur production from natural-gas sources amounted to 100,000 tons in 1950, Dirksen said, or 1.7 per cent of total sulfur output in the nation. By 1955, he said, production should reach 750,000 tons, or 9 per cent of the total.

Radioactive tracers . . . A radioactive tracer for injection waters in waterflooding is desirable because of the detectability of radioactive materials in extremely-low concentrations and the portability of radiation-detection apparatus.

This was a conclusion made in an address by H. N. Dunning, J. Wade Watkins, and C. J. Wilhelm, all with the Petroleum Experiment Station of the U. S. Bureau of Mines at Bartlesville.

One criterion of a suitable tracer is its ability to be detected in the field rather than by laboratory examination.

The choice of a radioactive tracer is also influenced by the type and intensity of radiation, half-life, cost, and availability of the isotope.

Dr. Edgar C. Britton, director of organic research for the Dow Chemical Co., Midland, Mich., and national A.C.S. president, pronounced a new standard for industrial chemical research in what he termed "100 per cent material accounting."

This, he said, is a practice in which the researcher overlooks nothing or wastes nothing in chemical processing.

The principle calls for utilization of all the byproducts from a chemical process. When properties of these byproducts are evaluated and uses for them determined, these materials in some cases, can become of considerable economic importance.

Discovery of a new chemical compound should not be the end point of chemical research, Dr. Britton continued. Rather, enough material should be produced for scientific and exhaustive testing. In this way, possible valuable uses for the substance will not be overlooked.

Ringwood Gas Price Sought

OKLAHOMA CITY.—Hearings will be held before the Oklahoma Corporation Commission here January 6 on two petitions seeking price fixing for casing-head gas in Ringwood multizone oil field of Major County, Oklahoma.

A motion has been taken under advisement by the commission to dismiss the petitions, based on the question of the commission's authority.

A price of 10 cents per M.c.f. is being asked for the Manning and the Cherokee sand zones. The petitioners, W. D. Greenshields, Ponca City, Okla., and Stanley Coppock, hold royalties in scattered tracts throughout the field.

Warren Petroleum Corp., operator of a natural-gasoline plant and gathering system in the field, and Oklahoma Natural Gas Co., which is purchasing gas from Warren's plant, both oppose the petitions.

Opposition of the two companies is based on the fact that their current purchase contracts are predicated on amortization of the plant.

WEST COAST

Army Abandons Camp to Oil

SANTA BARBARA.—The Government decided last week that it will be cheaper to close down an Army camp in California than to buy out the subsurface mineral rights of the former owners of the land on which it is located.

The Defense Department announced that because of recent discoveries of

oil at Camp Cooke, near Lompoc, Calif., the camp will be closed and its training activities transferred.

Camp Cooke consists of some 84,190 acres of land, the majority of which is government-owned subject to subsurface mineral rights retained by the owners.

Drilling was suspended during the war but has since been renewed, with successful results by Union Oil Co. of California.

When the question of the camp's future came up for consideration, the department concluded the cost of extinguishing the existing sub-surface mineral rights would be prohibitive and would exceed the Government's present investment in the camp.

CANADA

Exploration Up

Record 185 parties active in West Canada provinces

CALGARY. — Geophysical exploration in western Canada is at an all-time high, with a total 185 parties currently active in the field.

Of the 185, 166 are seismograph, 15 are gravity meter, and 4 are magnetometer crews. The number of seismograph crews has increased by two over the previous month.

Alberta led the provinces with a total of 133 crews in operation, up 6 over the previous month, including 122 seismograph and 11 gravity meter crews. Saskatchewan reported 38 seismograph, four gravity meters, and three magnetometer crews for a total of 45, down one from the previous month.

There were four active parties in British Columbia, three seismographs and one magnetometer. Manitoba had three seismograph crews in the field. The Northwest Territories reported no active crews due to the onslaught of the Canadian winter.

Comparisons . . . One year ago there were 152 active parties in the field, 117 2 years ago, and 101 in western Canada in 1949. Canada's share of active geophysical parties in North America currently is nearly 20 per cent.

Alberta is second to Texas in terms of geophysical activity with 133 crews. The current number of active fields in Saskatchewan is 45, an increase of 15 over a year ago.

Six major companies are operating 86 of the crews, headed by Imperial Oil, Ltd., with 22. More than 36 other companies or groups other than the 6 majors have the remaining 99 parties under contract, each with from 1 to 4 active parties.

Crude Line Completed

EDMONTON, Alta.—Canadian Gulf Pipe Line Co.'s 115-mile crude line under construction from Big Valley to Edmonton is expected to be placed in operation by December 1.

A 12-in. main line into Edmonton will carry crude from central Alberta fields of Big Valley, Fenn, Stettler, New Norway, Malmo, and Duhamel. Gathering lines have been laid in these areas and small pumping units are under construction at Duhamel and New Norway. A larger unit, with tankage, is being built at Stettler.

The new line will deliver crude to the Edmonton refineries and the western terminal of the Interprovincial pipe line. Initial capacity of the line will be 35,000 bbl. daily, and the initial operating load will be 10,000 to 11,000 bbl. daily.

Appeal Involves Royalties

EDMONTON, Alta.—Judgment has been reserved by the judicial committee of the Imperial Privy Council in London on an appeal by the province of Alberta involving its right to collect royalties on petroleum and natural gas produced from land belonging to Huggard Assets, Ltd.

The Alberta courts held that the province had no right to collect royalties, and this judgment was upheld by the Supreme Court, from which the present appeal is being taken. The final judgment will affect extensive oil and gas areas in western Canada.

Products Flowing to Toronto

TORONTO.—The first pipe-line delivery of petroleum products to Toronto began early this month as Imperial Oil, Ltd., reported receipts of gasoline at the company's tank farm in the Toronto Harbor area.

The 188-mile line originates at Imperial's expanding Sarnia refinery on the St. Clair River north of Windsor and moves products to the London, Hamilton, and Toronto areas.

The main line comprises 132 miles of 12-in. pipe from Sarnia to Waterdown and 56 miles of 10-in. pipe from Waterdown to Toronto. Two 6-in. spurs extend 6½ miles from Waterdown into Hamilton, making a 1-mile submerged crossing of Hamilton Harbor. The line has been in operation to London since early March, and deliveries to Hamilton began in early October.

The system will handle two grades of gasoline, diesel oil, stove oil, and furnace oils, at the rate of 39,000 bbl. daily. This capacity can be increased with the addition of another pump station.

Total cost of the system is placed at $11,000,000. Comstock-Midwestern, Ltd., of Leaside, Ont., was the general contractor.

ROCKY MOUNTAIN

Severance Tax Defeated

DENVER.—Colorado voters rejected by about 2 to 1 a proposed constitutional amendment in the recent election which would have permitted the state to levy a 5 per cent severance tax on the gross value of all oil and gas produced within its boundaries.

The vote was hailed by oil men in the area as a tremendous victory for industry in the Rocky Mountains.

The preelection battle over the severance-tax amendment developed into one of the state's hottest political scraps. In an effort to get the amendment approved by the public, which several times before had refused to endorse like proposals, proponents of the tax earmarked all revenues from it for state schools.

Early in the campaign, oil men banded together to form an organization called Colorado Oil Industries, Inc., to wage the battle against the tax. One of the group's principal arguments, pounded home by leaflets, newspaper and radio advertisements, was that the state already had so much earmarked revenue that it could no longer legislate and appropriate effectively.

Shell Tests Montana Strike

DENVER.—The latest discovery in the Montana portion of the Williston basin has indications of being one of the best.

Shell Oil Co.'s Dawson County wildcat, the 21-33-B-NP, 14 miles southwest of Richey pool, where the company made the first Montana Williston discovery, flowed at the rate of 1,675 bbl. of 49°-gravity oil per day.

Although Shell has not released official data on formations and current testing, the production is reported from the Devonian.

With successful completion of the present well there will be seven widely scattered pools in a north-south trend along the west side of the basin in Montana. Gravity of the oil at the discovery, 49°, is higher than that found in any of the other Montana Williston wells, with the majority of gravities ranging between 32° and 38°.

Testing is continuing at the wildcat, which is separated from Richey pool by two dry holes.

AFRICA

Somali Terms Revealed

Sinclair Somal granted right to explore for 9 years and produce until 1992 any oil discovered on the concession

Dahl M. Duff

THE rights which a new Sinclair Oil Corp. subsidiary recently obtained in the former territory of Italian Somaliland in East Africa provide for an exploration period of up to 9 years, followed by an exclusive production concession in case oil is found.

The concession was granted under terms of the mining regulations promulgated in the territory on August 15, 1951, and some further features of the concession agreement have been revealed by Giovanni Fornari, head of the Italian trusteeship administration on behalf of the United Nations.

Two oil concessions (see accompanying map) have been granted. Approximately 52 per cent of the country, or about 97,000 of the total 194,000 sq. miles, is included in the concession obtained May 10 of this year by Sinclair Somal Corp. Another considerably smaller area adjoining Sinclair's area to the north was taken by Soc. Italiana Mineraria Somala, which is affiliated with the Italian Government oil company, Azienda Generale Italiana Petroli.

The new Sinclair Somal concession represents a substantial enlargement of Sinclair's exploration operations in this part of the world. Adjoining its new concession on the west is Ethiopia, where Sinclair has been doing exploratory work since the end of the war with its second well now being drilled a short distance from the border.

Important additional support was given to the program recently when three United States companies—Continental Oil Co., Ohio Oil Co., and Amerada Petroleum Corp.—each bought a one-sixth interest in Sinclair Somal for a total half share of the operation. Sinclair, with the remaining half, continues as the operator.

Features of concession . . . Section 16 of the 1951 regulations provides that, in the event that the exploration program involves considerable work and the installation of large equipment, such as in the case in the exploration for liquids and gas hydrocarbons, a special agreement can be entered into between the party concerned (the applicant) and the trusteeship administration. In this, the administrator has the advice of a committee of experts which are appointed each year to assist in connection with concession applications.

The Sinclair concession recently obtained in the territory conforms to the general terms laid down in the regulations, but the specific provisions are in the negotiated agreement. This agreement lays down all conditions for both the exploratory period and the later exploitation, or production, period of the operation. The Soc. Italiana Mineraria concession was handled similarly.

The exploration permit has a life of 9 years with the understanding that, if oil is found within this period, the company will have exclusive rights to operate the properties over a period of 40 years beginning with the date of the agreement (May 10 in Sinclair's case).

Drilling commitment . . . Five years after the date of the agreement, the company is required to release 25 per cent of the concession area, and 5 years later, another 25 per cent of the initial acreage must be turned back. The company was required to start exploration work 120 days from the date of the agreement and must have a well drilled within 4 years from this date.

The company pays an annual fee for the concession in the exploration stage, and the agreement provides that another fee is assessed on a per square kilometer basis after a discovery is made. In addition, the trusteeship administration receives royalties on production. Neither the amount of the fees nor the rate of the royalty provided have been disclosed as yet.

Labor agreement . . . Relationships between the administration and prospecting companies are governed by the agreement. This requires that the companies hire unskilled labor on location, train native workers, and, if operations are successful, that sanitary and educational facilities such as hospitals and schools be erected for the local population.

Somalia, as the former Italian Somaliland is now known, is scheduled tentatively to become a completely independent state in 1960. This was ordered by the United Nations General Assembly in November 1949. In the meantime it will be administered by the Italian-U.N. trusteeship. The territory has an estimated population of 1,300,000. The capital and only port is Mogadiscio.

Classes of concessions . . . The detailed Somalia mining regulations which are applicable to minerals as well as to petroleum, set up three classes of concessions: (1) the prospecting license which does not bestow preferential status and is mainly to allow reconnaissance exploration; (2) the exploration permit good for 9 years with extensions; and (3) the full exploitation concession.

The regulations contain safeguards requiring that the work be pursued actively and declare that expropriation of the concession title is possible only in case of action brought by mortgage creditors. The regulations place no restrictions on foreign enterprises, requiring only that the holder of a full exploitation concession must have a residence within the territory.

French to Drill in Algeria

Exploratory rights have been granted by the Government of Algeria to two French companies in a part of the Sahara Desert in southern Algeria.

A recent report from Paris said the two companies, Cie. Francaise de Petrole and Soc. Nationale des Petroles

en Algerie, were planning to begin drilling in the near future, using heavy equipment capable of 12,000 ft. or more, at Berraine near Ghardala.

The two companies were reported to have been granted rights in an area extending from Biskra in the north to El Golea in the south, Figuig in the west, and the Tunisian frontier in the east.

Two other companies, including Shell, are also seeking exploration concessions in southern Algeria. It was reported Shell is contemplating operations through a subsidiary, Cie. Petroles de'Algerie. The other operator is Regie Autonome des Petroles, which will work through a subsidiary, Cie. de Recherches et d'Exploitation du Sahara.

All these companies, with the exception of Shell, represent French interests. C.P.F. is a major refining and distribution company in France and holds 24.75 per cent in the Iraq Petroleum Co., Ltd., Group.

Tunisia Discovery

French oil company makes strike southwest of Tunis

AN oil discovery is reported to have been made early in November by a French company in northwestern Tunisia.

The well, 1 Bahloul, is located near the village of Maktar, about 78 miles west of Sousse and approximately the same distance southwest of Tunis.

There were no details on the operation. It was reported that shows had been encountered at about 400 m. (about 1,300 ft.) and that oil production was obtained after the well was taken deeper to around 500 m. (1,650 ft.).

The operating company, SEREPT (Soc. des Recherches et d'Exploitation des Petroles) is backed by the French Government and is one of three companies now carrying on exploratory work in Tunisia. The other two are Soc. Nord-Africaine des Petroles (Gulf) and Cie. des Petroles de Tunisia (Shell). Serept holds minority interests in the Shell and Gulf ventures.

SEREPT itself is running three rigs in Tunisia. One is on the Bahloul well, another on Cape Bon, where some gas production has been developed, and the third on a well known as Chott Sedjadj.

Gulf and Shell have one rig each on exploratory work in Tunisia. Gulf is drilling the Sainte Juliette structure about 18 miles north of Sfax on the road to Sousse. The hole is now down below 7,500 ft. Shell abandoned its initial test at Zeramdine and is now drilling a second wildcat at Ktitir, southwest of Sousse.

LATIN AMERICA

Rush for Concessions

Four major U.S. operators among 13 companies seeking acreage under Peru's new oil law; Sechura Desert popular

A SURPRISING heavy rush for acreage has occurred in Peru with the opening period for concession applications under the country's new petroleum law.

Thirteen companies filed applications which are reported to cover approximately 4,000,000 hectares, or about 9,800,000 acres. Eleven of these asked for areas in the Sechura Desert, the most promising wildcatting territory in Peru.

Overlaps and filings for the same areas were common in the applications for the Sechura acreage. It is expected to be several weeks before the Ministerio de Fomento y Obras Publicas, which administers petroleum matters, straightens out the applications and prepares for the auctioning at which acreage covered by more than one application will be awarded.

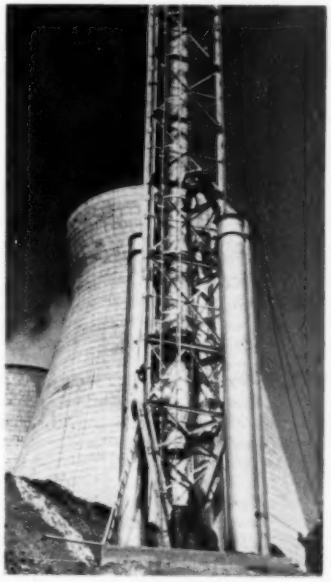
Applicants . . . The 11 companies applying for concessions in the Sechura included four important United States operators: Gulf Oil Corp., Richmond Petroleum Co. of California (Standard Oil Co. of California), Conorada Petroleum Corp., and International Petroleum Co., Ltd. All of these companies have carried on some preliminary geophysical work in the region. International is the principal company now carrying on an integrated operation in Peru.

Other foreign companies seeking Sechura acreage were two Canadian organizations, Seaoil, Ltd., reported to be affiliated with Ventures, Ltd., and Peruvian Oil & Minerals, Ltd., and one company representing Argentine interests. The other four applicants in the Sechura were Peruvian—Cia. Peruana de Petroleo El Oriente, Cia. Peruana de Petroleo, Peru Oil Concessions, and the Wiese interests.

Aside from these 11 applicants, one company, Consorcio Minero, asked for an area of 10,000 hectares in the vicinity of Nazea on the Peruvian coast about 200 miles south of Lima. The other applicant seeking acreage other than in the Sechura was Cia. de Petroleo Ganzo Azul which filed for a concession in Peru's trans-Andean Montana. Ganzo Azul now has a small integrated operation in eastern Peru about 2,800 miles upstream from the mouth of the Amazon.

Some of the companies asking acreage in the Sechura filed for both exploration and exploitation concessions on different parcels. Since overlaps were numerous, apparently most of the best areas will go on the exploitation basis which is given preference. For this type of concession, the limit is 100,000 hectares.

Action a surprise . . . The amount of interest shown in prospective Peruvian exploration was a surprise to some officials who had been following developments in Peru. The new law which was passed early this year *(The Oil and Gas Journal, March 3, page 63)*, was received with some reservations in the industry, especially in view of some of its tax features.



New Type Stack

A new type of refinery flare stack is shown here being erected by Anglo-Iranian Oil Co., Ltd., in Britain. The 250-ft. stack is supported by cables and rests on a small "registering ball" at the base (The Oil and Gas Journal, October 6, page 82). A similar design has been used for a television mast in Britain, but this is said to be the first use in the petroleum industry. Five of the stacks are being erected at A.I.O.C.'s refineries in the United Kingdom.

Assigned New Post

A.I.O.C. names Eric Drake as Heath Eves' successor

ERIC C. DRAKE, who for 14 years has served Anglo-Iranian Oil Co. in various Middle Eastern countries, has been named the company's United States representative.

Drake, who will assume his new post in New York December 1, will succeed W. D. Heath Eves, who is resigning.

He was general manager of the company operations in Iran and Iraq last year when Premier Mossadegh nationalized Iranian oil properties. In recognition of his services during that time he was appointed a Commander of the British Empire by King George VI.

Drake was graduated with honors from Cambridge University. He qualified as a chartered accountant and was a winner of the William Quilter prize for the best annual paper on auditing. He joined Anglo-Iranian in 1935.

In 1938 he went to Iran and 6 years later became commercial superintendent at Abadan. For a year he was commercial manager in charge of company sales in Iran and Iraq. Later he was appointed manager of Rafidain Oil Co., Iraq.

During 1948 and 1949 he conducted negotiations with the Syrian Government on behalf of Middle East Pipelines, Ltd.

He returned to Abadan as general manager of company operations in 1950. Following the Iranian oil nationalization he went to Australia. There he negotiated with both the Federal and Western Australian Governments on the Kwinana Oil Refinery agreement which was signed last March.

He was a member of the successful Rowing Club crew which visited Australia in 1934 for the Melbourne Centenary celebrations.

Glenn H. Pickett, tool pusher for Guy Mabee Drilling Co., has been transferred from Plains to Stanton, Tex.

Jack Symthe has resigned as a geologist for Frontier Refining Co. to become a consultant at Denver. He has been with Frontier 4 years and prior to that was a geologist for The Texas Co.

F. W. (Dick) Borden, Los Angeles, general superintendent of the California district for Sunray Oil Corp., has been appointed manager of California operations for the company. He succeeds **R. E. Foss,** who recently was transferred to general offices in Tulsa as vice president and manager of the exploitation department.

M. Wendell Ramsey has been appointed assistant general manager of pipe-line operations for Gulf Oil Corp. in the United States and Canada. Ramsey, who since 1950 has been in the general office executive department in Pittsburgh, has been transferred to Houston. Before joining Gulf he was associated with Standard Oil Co. (Ohio).

J. K. Horton, president of Pacific Public Service Co., San Francisco, has been elected a director of the American Gas Association. He succeeds **Ernest G. Lawson,** former president of the Pacific Coast holding company, who resigned.

Leon Krause has been promoted to division engineer in charge of secondary-recovery operations in the Henderson, Ky., division of Ashland Oil & Refining Co. **Paul Sturm** has joined the division staff at Henderson as a petroleum engineer. **M. M. Mayes** and **Loren Rienbolt** have been promoted from pumpers to production foremen in the Grayville, Ill., district. **Jack Mason** has joined Ashland's eastern division as petroleum engineer at Oil Springs, Ky., and **J. D. Copen** has been employed in the geological department at Ashland, Ky. **Jack Davis,** production foreman, has been transferred from the Marine, to the Salem, Ill., district.

J. Ed Warren, deputy petroleum administrator of the Petroleum Administration for Defense, left Washington, D. C., last week for a tour of Middle East oil activities. He will get first-hand information on operations under the Defense Expansion Program.

A. S. Donnelly, vice president of the Mid-Continent division of Honolulu Oil Corp. at Midland, Tex., has been elected to a 3-year term as director of the Texas Manufacturers Association.

Lewis F. Wells, Sun Oil Co., has been elected president of the Intermountain Association of Geologists. Other officers elected recently in Salt Lake City are: **Ernie Tisdale,** Cities Service Oil Co., vice president; **Bill Heiny,** Continental Oil Co., secretary, and **Stan Collins,** Stanolind Oil & Gas Co., treasurer.

F. H. MacLaren has been appointed research associate and **L. T. Crews** has been named a group leader in the Whiting, Ind., research laboratory of Standard Oil Co. (Ind.). MacLaren, who joined Standard in 1925 as a research chemist and became a group leader in 1941, will be assigned to research on wax quality and evaluation. Crews, who was appointed a chemist for the company in 1951, will be in charge of research and development work on asphalts, petrolatums, and candles.

Receives Institute Award

T. G. Roehner (right) is shown as he was presented an award from the National Lubricating Grease Institute for outstanding service to the institute. Roehner is director of the technical service department of Socony-Vacuum Oil Co., New York. The award, a desk clock with barometer and thermometer, was made at the institute's annual meeting banquet October 27 by outgoing President G. E. Merkle.

PERSONALS

C. E. Skiles and **Joe McGuire** have organized the Mount Carmel Drilling Co. at Mount Carmel, Ill.

Fred Schall, chief geologist for Texas Gas Transmission Corp., has been transferred from Shreveport to the company's new offices at Houston. Establishment of the Houston offices is part of the company program to obtain new sources of natural gas.

Charles D. Riden has been promoted to assistant division superintendent for Ashland Oil & Refining Co. at Oklahoma City. **Lewis J. Bicking, Jr.,** petroleum engineer at Oklahoma City, has been transferred to Shreveport.

Albert L. Nickerson, vice president and director in charge of foreign marketing for Socony-Vacuum Oil Co., Inc., has been appointed a director of City Bank Farmers Trust Co., trust affiliate of the National City Bank of New York.

William F. Konode, a former chairman of the Texas Railroad Commission, has been appointed a director of New Continental Co. of Canada, Ltd. He left his Texas position in 1938 to become the first chairman of Alberta Petroleum and Natural Gas Conservation Board. He served in the latter position until 1940.

Bruce A. McCandless, formerly assistant to the director of the American Gas Association laboratories in Cleveland, has been appointed assistant to the managing director of the A.G.A.

G. G. Green, Laurel, Miss., has been named president of the Mississippi-Alabama division of the Mid-Continent Oil and Gas Association. Elected vice presidents were: **Ed Brunini,** Vicksburg, Miss.; **E. D. Kenna,** Jackson, Miss.; **James L. Duffy,** Grove Hill, Ala.; **A. B. Friend,** Sardis, Miss.; **Dennis Granberry,** Laurel, Miss.; **Buford Yerger,** Hattiesburg, Miss.; **Barnett Serio,** Natchez, Miss., and **J. Finely McRae,** Mobile.

H. S. Brigham, superintendent of the Fruitvale district for Western Gulf Oil Co., has been appointed manager of exploitation in the California area. He has been transferred from Bakersfield, Calif., to Los Angeles. **J. B. Wharton,** district superintendent of Oak Canyon field, has been promoted to executive assistant to the vice president.

A.P.I. Elects Board of Directors for 1953

CHICAGO.—The following new directors were elected at the American Petroleum Institute meeting here last week:

Z. K. Brinkerhoff, Jr., Brinkerhoff Drilling Co., Casper, who succeeds Paul Stock in the production group.

T. E. Swigart, Shell Pipe Line Corp., Houston, who succeeds Alexander Fraser in the refining group.

Gage Lund, Standard Oil Co. of California, San Francisco; James W. Liddell, Continental Oil Co., Denver; R. L. Milligan, Pure Oil Co., Chicago, and James E. Dyer, Sinclair Oil Corp., New York. They succeed, respectively, H. D. Collier, J. A. Lentz, Henry M. Dawes, and A. E. Watts in the marketing group.

Davis Bovaird, Bovaird Supply Co., Tulsa, and Otto Hammer, Security Engineering Co., Whittier, Calif., succeeding, respectively, Fred M. Mayer, and Theodore Sutter in the supply group.

Paul Endacott, Phillips Petroleum Co., Bartlesville, Okla., succeeding C. R. Williams in natural gasoline.

W. K. Whiteford, Gulf Oil Corp., Pittsburgh, and M. J. Rathbone, Standard Oil Co. (N. J.), New York, succeeding, respectively, J. Frank Drake and John R. Suman in the at-large group.

The board of directors also reelected for 2-year terms the members-at-large, elected by the board itself, whose terms expired with the thirty-second annual meeting. These directors include: John C. Case, Walter S. Hallanan, William F. Humphrey, W. A. Jones, H. T. Klein, B. H. Markham, S. B. Mosher, Henry D. Moyle, T. Rieber, and A. A. Stambaugh.

The board accepted resignations of E. DeGolyer and Wirt Franklin. To fill their unexpired terms the board elected F. Windfohr, Nash & Windfohr, Fort Worth, and Roland V. Rodman, Anderson-Prichard Oil Corp., Oklahoma City.

All other board members whose terms expired this month were reelected for 1953.

Glen V. Kersten, Fruitvale district engineer for Western Gulf Oil Co., has been appointed superintendent for southern San Joaquin Valley, California. **J. K. Beckett,** formerly assistant district superintendent in the Fruitvale district, has been appointed superintendent of production at Santa Maria, Calif.

Ivone St. G. Burn has resigned as director and vice president of Scurry Oils, Ltd., Canadian firm, to form a land service company in Calgary, Alta. **Dr. A. W. Nauss** has been appointed managing director of Scurry.

Charles C. Green, Jr., has resigned as a geologist for Cactus Drilling Co. to become a consulting geologist and independent operator. Before joining Cactus in 1951 he was with Texas Gulf Producing Co. as West Texas division geologist.

Arthur L. Saxton has been named senior project engineer, and **Hollister B. Sykes** is a new group head in Standard Oil Development Co.'s Esso engineering department, Linden, N. J.

Dr. William F. Krause has been appointed to the newly created position of technical manager of the Lemont, Ill., refinery of Globe Oil & Refining Co. **A. Cameron Dystrup** has been named to succeed Krause as chief chemist. **Amos C. Beavers** has been appointed manager of manufacturing, also a new post.

Harvey R. Fifer has been elected vice president of Brea Chemicals, Inc., a newly organized subsidiary of Union Oil Co. of California which will develop and manufacture chemicals from petroleum. He will be in charge of marketing.

N. C. Simpson, general manager of the Gulf Coast district of Gulf Oil Corp., has been named executive assistant to the vice president in Houston. Simpson succeeded **B. G. Martin,** who has resigned to head San Jacinto Petroleum Corp.

Myron G. Thomas, formerly district manager for Southern California Gas Co. at Pasadena, Calif., has been named head of new company division headquarters there. Thomas, who joined Southern California in 1934, became assistant manager in 1942 and district manager in 1946.

I. R. Cunningham has resigned as a director and comptroller of Creole Petroleum Corp. to accept a position with the producing coordination department of Standard Oil Co. (N. J.). **H. A. Jarvis** has been elected a director and **L. E.**

PERSONALS

Lowery has been appointed comptroller to fill the vacancies left by Cunningham. Jarvis has been associated with Creole and other Jersey Standard subsidiaries since he was employed in the Esso Standard Oil Co. Bayway refinery as a student engineer in 1930.

O. W. Heyden, assistant chief engineer for Shell Pipe Line Corp., has been named acting chief engineer. Heyden joined Shell Oil Co. in 1931 following graduation from Tulane University and was promoted to assistant chief engineer in 1938. Three years later he was transferred to Shell Pipe Line in the same position.

Vernon E. Briard, who received his Ph.D. degree in geology from the State University of Iowa last June, has been appointed a geophysicist for The Texas Co.

George E. Taylor has resigned as division geologist for Continental Oil Co. in Evansville, Ind., area to become head of the geological department of Sam D. Jarvis, Evansville producer. **G. E. Ebmeyer** has been promoted to exploration manager of the Jarvis organization.

Eugene A. Fortune, formerly an engineering trainee for Sunray Oil Corp. at Newhall, Calif., is working for a master's degree in petroleum engineering at Stanford University.

J. H. McReynolds, supervising engineer in the Gulf Coast division of Humble Oil & Refining Co., has been promoted to assistant district superintendent at Anahuac, Tex.

E. P. Hubbard, production manager for Gulf Oil Corp. in the Gulf Coast district and production adviser to the Gulf Coast general manager, has been named division production adviser to the vice president.

N. B. Martin, formerly staff assistant to the division producing operations adviser, has been promoted to assistant division producing operations adviser to the vice president of the Gulf Oil Corp. at Houston.

Joseph Neely, district geologist for Magnolia Petroleum Co. at Midland, Tex., has been promoted to senior staff geologist at the company's general offices in Dallas. **W. L. Moreman,** district geologist at Oklahoma City, has been transferred to Dallas.

J. R. McChesney, superintendent of the gas department at Fort Worth for Pure Oil Co., has been transferred to Chicago in that position.

Orbie N. Lambright, seismograph party manager for Cities Service Oil Co., has been transferred from Big Lake to Monahans, Tex.

John B. Sansone, senior exploitation engineer for Shell Oil Co. in the San Joaquin division at Bakersfield, Calif., has been transferred to the Los Angeles Basin division.

Robert H. Angevine, reservoir engineer for Sohio Petroleum Co. at Oklahoma City, has been appointed production engineer at Houston.

W. K. Neish, district superintendent for The Texas Co. at Craig, Colo., has been transferred to Glendive, Mont., in the same capacity.

A. E. Osborough, manager of the prairie region for British American Oil Co., has been named manager of the central (Ontario) region at Toronto.

George Locke has been promoted to general foreman of the electrical department at the Standard Oil Co. (Ind.), Whiting, Ind., refinery. He succeeds **B. C. Malick,** retired, and is in turn succeeded as assistant general foreman by **Russell Evans.**

Morris Bickley, relief maintenance foreman for the gas division of Pacific Gas & Electric Co., has been transferred from Needles to Avenal, Calif.

W. G. Bahan and **C. J. McFeely,** geologists, and **P. K. Fleming** and **R. J. Rousseau,** petroleum engineers, have organized a new consulting firm in Edmonton, Alta. The new company is Bahan, Fleming, McFeely & Rousseau, Ltd.

W. B. Howrey, formerly an engineer for Creole Petroleum Corp. in Las Piedras, Venezuela, joined Reynolds Metal Co. at Corpus Christi.

John R. Taylor, who is in the engineering training program of Atlantic Refining Co., has been transferred from Greggton to Midland, Tex.

Ernest O. Ohsol, formerly with the Esso Research Center of Standard Oil Development Co., has been appointed director of chemical engineering for Pittsburgh Coke & Chemical Co.

DEATHS

Charles S. Hill, 67, Denver independent producer, died November 10 in Chicago, where he had gone to attend the American Petroleum Institute meeting. He entered the oil business in Wyoming in 1923 and had been one of the outstanding operators in the Rocky Mountain region since that time. He retired November 1 after serving 4 years as president of the Rocky Mountain Oil & Gas Association. He was also a director of the Independent Petroleum Association of America.

R. B. Block, formerly a drilling superintendent for Arctic Contractors in Alaska, died in Whittier, Calif., November 3. He also had been associated with International Petroleum Co. in Peru and with Cavins Co., oil equipment firm, in California.

Samuel J. Brendel, 69, oil and gas producer, died November 6 in a Pittsburgh hospital. He was active in oil development in Ohio, Pennsylvania, and Texas.

Antoine Eugene Lacomble, 58, retired chairman of the board of Shell Development Co., died November 5 in San Francisco. He was president of the company from 1943 to 1948 and board chairman until has retirement 2 years ago.

Norman L. Carr, 66, independent oil producer, died October 31 at his home in Bay City, Mich.

Frank E. Spencer, 68, retired oil executive, died November 6 at Wautoma, Wis. He established Spencer Petroleum Co. in 1922 and remained as its president after it became a division of Socony-Vacuum Oil Co., Inc., in 1941.

Col. Edwin van Deusen Selden, 93, formerly an oil producer and refiner in the Pennsylvania area, died November 9 at his home in Oil City, Pa. He had been a member of the Oil City Oil Exchange and was a charter member of the National Petroleum Association.

Annual A.P.I. Section

Evaporation Loss of Petroleum—A Symposium

Stress Failure in Big-Inch Pipe

Water-Imbibition Displacement

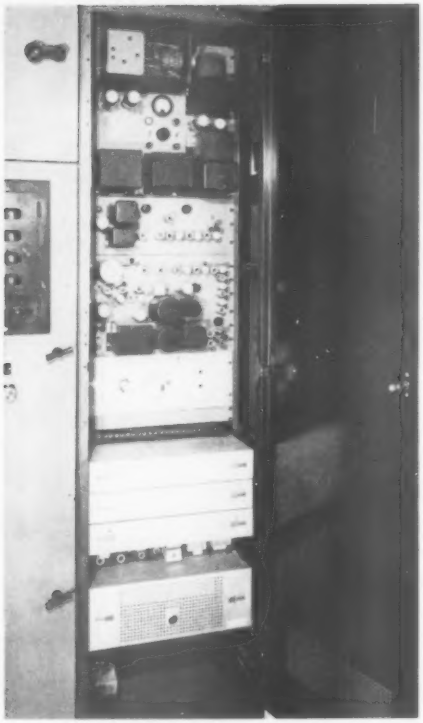
Use of High-Speed Computing Machines

Microwave Control of Pipe-Line Pump Station

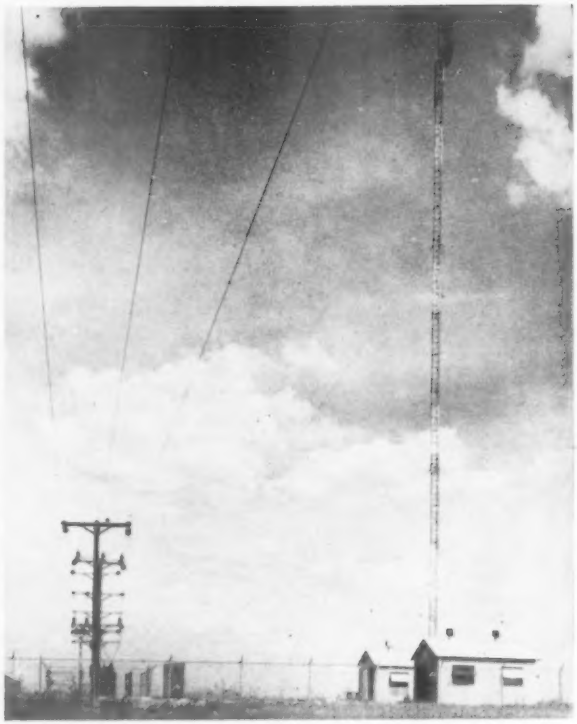
Outlook for Oil-Country Tubular Goods

Thermodynamic Properties of Hydrocarbons

. . . Other Articles and Features



MICROWAVE RADIO and channeling equipment required at the remote station. Fig. 1.



GENERAL VIEW of remote station, showing antenna tower. Fig. 2.

Microwave Control of Pump Station Raises Line Capacity at Minimum Cost

Savings in labor cost alone pay out additional investment in 9 months of operation

by J. R. Ellis*

IT recently became necessary to increase the capacity of an 8-in. 85-mile-long products pipe line by the installation of an intermediate booster station at a point on the line approximately 32 miles from the initial pump station.

This booster station takes advantage of recent developments in automatic controls and communication devices which have been made available to industry. The use of these devices makes it possible for the station operators on duty at the initial pump station to observe operating conditions at the remote booster station.

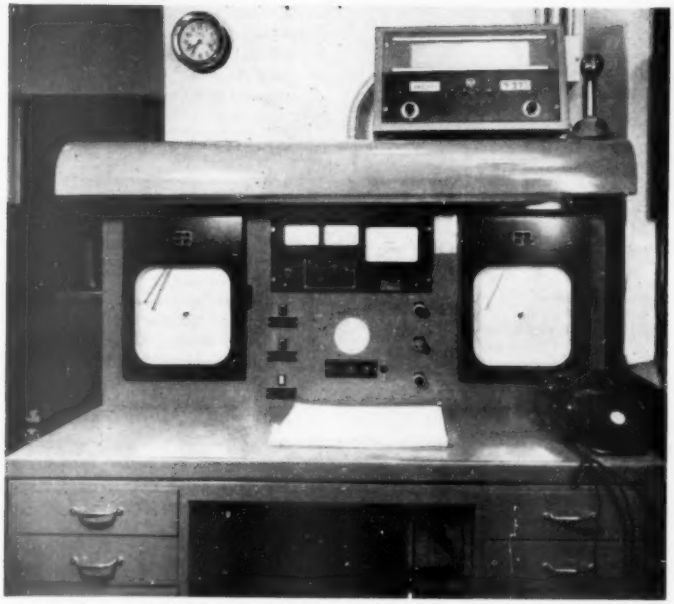
These observations permit regulation of the pumping rates in a manner which insures operation of the pipe line at maximum throughput by the utilization to best advantage of the power available at both the initial and booster stations. The remote station may be stopped and started from the initial station as required.

A microwave radio system provides the communication channels for the supervisory controls and for the telemetering equipment which makes the remote operation possible. Radio was chosen for this service for several reasons—one being that it could be installed at a cost one-third less than that required to provide a wire-line circuit between the stations. Installed cost of the radio circuit was approximately $600 per physical mile. Circuit availability and maintenance cost were also prime considerations.

Frequency band . . . The microwave radio system operates in the 940 to 960-megacycle frequency band, which is a comparatively low-frequency one insofar as microwave is concerned. Some people in the radio field are reluctant to consider such a low frequency to be true microwave, as the wave length is approximately 1 ft. long as compared to the actual microscopic length of extremely high frequencies.

This frequency band was selected

* Sunray Oil Corp., Tulsa. Presented at thirty-second annual A.P.I. meeting, Chicago.



CONTROL CONSOLE shown here is used for operation of remote station. Fig. 3.

because of the reliable and simple radio circuits employed. Also, the standard type radio tubes used for these frequencies have a better record for long service life than some of the special types required by the higher frequencies. The propagation characteristics of the selected frequency are such that there appears to be less fading and loss of communications caused by varying atmospheric conditions than are experienced when higher frequencies are used.

The 940 to 960-megacycle microwave frequency band offers one of the best means of communication for point-to-point service over distances up to 300 miles. It provides for simultaneous operation of up to six voice channels. From 9 to 18 telemetering, remote-control, or supervisory circuits may be substituted for each voice channel; and this is accomplished by utilization of the single-sideband suppressed-carrier type of multiplex apparatus, similar to standard telephone carrier equipment.

Radio equipment . . . Fig. 1 shows all of the microwave radio and channeling equipment required at the remote station. This equipment provides a two-way voice channel to the control console at the initial station, and receives and transmits the tone signals which operate the various supervisory and telemetering equipment.

The power output of the microwave radio transmitter is 2 watts. This small amount of radio energy is conducted to the antenna through a gas-filled coaxial cable. The antennas consist of small dipoles, with parabolic reflectors 6 ft. in diameter, which concentrate and focus the radio waves in the same manner that a beam of light is focused, so that a maximum amount of the energy radiated is directed toward the receiving antenna.

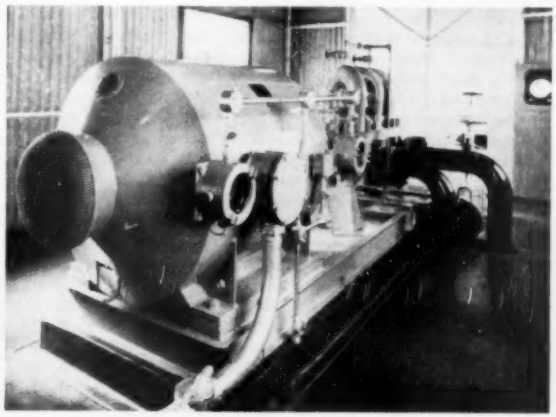
Two antennas are required at each location—one for transmitting and one for receiving. These are mounted on steel towers 170 ft. high at both the remote and the control stations. The tower height provides the necessary line-of-sight path between the stations without requiring an intermediate relay station.

Fig. 2 is a general view of the remote station. It shows the antenna tower, which is located between the control building and the building which houses the pumping unit.

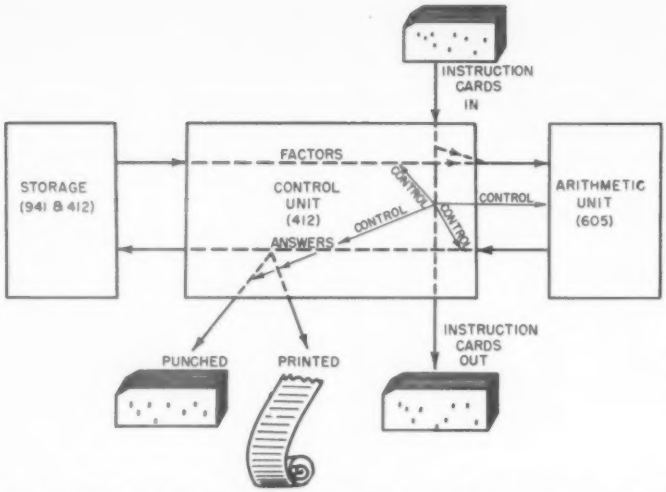
Operation . . . The remote station is controlled from the console shown in Fig. 3. The console is located in the office of the initial pump station in such a position that the station operator may observe operating conditions at both the local and the remote stations. The panel of the console is equipped with recording instruments which give a continuous record of the suction and discharge pressures, as well as the kilowatt-hours of power being used at the remote station. Signal lights give a visual indication of operating conditions, and a horn is sounded in the event the remote station goes

(Continued on page 410)

INTERIOR VIEW of remote-station control building. Fig. 4.



INTERIOR VIEW of pump room at remote station. Fig. 5.



SCHEMATIC DIAGRAM OF CARD-PROGRAMED CALCULATOR. The unit exercises control, acting on instructions from cards. It prints, punches, and stores the answers. Fig. 1.

NEW LIGHT ON . . .

Use of High-Speed Computing Machines—*for oil-production problems*

Superfast electronic "brains" soon to be available should make it easy to obtain answers to problems previously beyond practical consideration.

by W. A. Bruce*

RECENT developments in high-speed computing machines seem likely to lead to a new technology for the prediction of petroleum-reservoir behavior. Electronic devices will soon be employed to speed up reservoir-engineering work and to permit detailed and complete solutions to problems previously unsolved.

Reservoir engineers have always had to do a large amount of computation work for the solution of the simplest problems. Even so, they have had to oversimplify their problems because of the enormous number of computations necessary to carry out any job with the degree of detail desired. High-speed automatic computers soon to be available should make it easy to obtain answers to problems previously beyond practical consideration.

One example of a difficult reservoir problem is that presented by the pool operating with both a gas cap and water drive. It has been estimated that to study the behavior and plan the future operation of a complex reservoir involving water influx, gas injection, and gravity drainage would require over 100 million arithmetic operations if the engineers applied all of the technology now available to them.

A good computer, using one of the conventional desk calculators, can do between 500 and 1,000 arithmetic operations per day. Thus a 100-million-calculations problem would take 10 men using desk machines at least 30 years. This staggering computing job has prevented even a research investigation of some of the possibilities of reservoir-behavior prediction.

About 10 years ago Carter Oil Co. developed an analog computer[1] designed only to predict the behavior of water-drive pools. This machine has worked out very satisfactorily for the restricted class of reservoir problems for which it was designed. In addition to being reliable, this machine will do in an hour a job that would take a man several months.

With the development of high-speed general-purpose computers, it is possible that all phases of reservoir behavior predictions will soon be as easy to handle as the water-drive problem is now.

These giant "electronic brains," which for the last 6 years have been laboratory tools, are about to emerge as production models. So far they have been custom built and, before 1951, no two had been made alike. Each one has been made obsolete by new developments before it could be finished. However, now several of these computing giants are in daily operation. A number of companies offer them for sale and about 10 will be installed for defense, commercial, or government use this year.

This new type of electronic computer differs from the desk machine calculator not only because it is faster, but because it can automatically sequence millions of operations without human intervention. The term "brain" is very apt because the machine not only has to be able to follow a series of instructions, it has to retain in a "memory" thousands of numbers; furthermore, it has to decide at various points what to do next based upon what has resulted from the calculations up to that point.

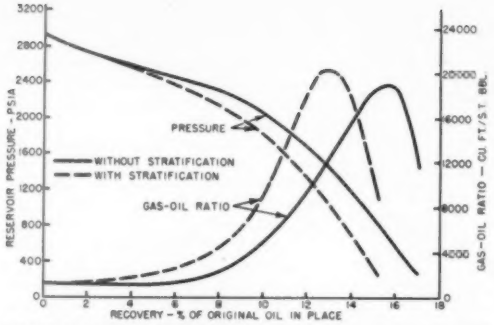
Characteristics of Some Automatic Computing Devices

Computing machines may be classified as either digital or analog. An ordinary adding machine or desk calculator is an example of a digital calculator. Numbers to be held or memorized are held as digits and when a result has more digits than places in the machine, "rounding off" has to be done either by throwing away part of the number or by arbitrarily making the result larger.

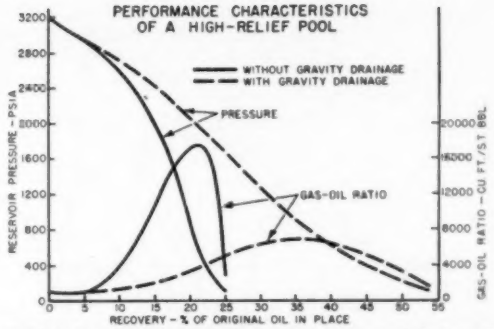
The analog type of computer employs physical phenomena that are analogous to the mathematical operation to be carried out. An electrical network set up so that current flow is equivalent to fluid flow is an example of an analog computer. In such a device answers can be read as voltages or currents; whereas, in a digital computer, the answer is always in whole numbers. The accuracy of an analog computer is limited by the ability to measure the analogous physical property.

I.B.M. card-programed electronic cal-

*Carter Oil Co., Tulsa. Presented at thirty-second annual A.P.I. meeting, Chicago.



RESERVOIR STRATIFICATION tends to reduce oil recovery and promote rise in gas-oil ratio. Fig. 2.



INFLUENCE OF GRAVITY DRAINAGE on pressure behavior and gas-oil ratio is indicated here. Ultimate recovery with gravity drainage is much higher. Fig. 3.

culator . . . The C.P.C. is an intermediate speed computer just beginning to be used by a few oil companies. It is the logical outgrowth of International Business Machine's punched-card accounting machines and is merely an aggregate of modified accounting machines plus an external "memory" or number storage unit.

The punched-card machines have recently had wide acceptance for a number of accounting, recording, tabulating, selecting, storing, and computing chores. These machines will undoubtedly be even more widely and effectively used in the future. Their basic operation is essentially as follows: Coded information is punched into a card. This card has 800 marked positions on it and can be used to store 8 numbers of 10 digits each. The machines are set so that if a hole is punched in any one of these 800 spots an electrical pulse goes through this hole as the card passes through the machine. It is by these electrical impulses that numbers or instructions are stored, operated on, or transmitted.

These punched-card accounting machines have grown so much in complexity that on a single card all of the pertinent data on an oil lease may be punched in a single operation requiring 0.4 second. The lease name, its code number, the month, number of barrels of oil produced, the fraction owned by the royalty owner, the price of oil, and the total value to the royalty owner can all be put on the card and leave room for four more six-digit numbers or equivalent information.

The card-programed calculator is composed of the 605 electronic calculating punch, the 412 accounting machine, and the 941 memory unit. In handling the cards and getting most out of the C.P.C., some auxiliary equipment is used; this includes a key punch to prepare the cards, a sorter, a collator, and a reproducing punch.

Fig. 1 shows how the I.B.M. 412 accounting machine acts on instructions punched into the cards, to select arithmetic operations to be carried out. Instruction cards and numbers are fed into the 412 unit, which controls the operations to be carried out by the arithmetic unit. Answers are sent back to the 412 for storage, punching, or printing. Subroutines can be wired so that several arithmetic operations may be carried out automatically from a punched signal.

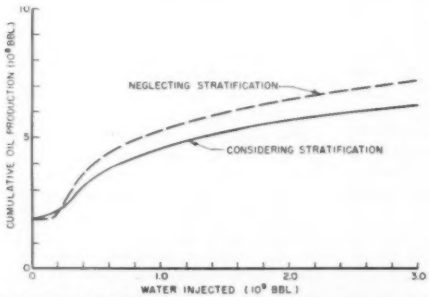
Table 1 shows a few of the subroutines which the C.P.C. at the Carter research laboratory has been coded to carry out from a punched-card signal. The C.P.C. can handle as many as 150 of these cards per minute. This fixes the maximum speed of a coded arithmetic operation at 0.4 second.

TABLE 1—OPERATIONS REQUIRING ONE PROGRAM CARD EACH

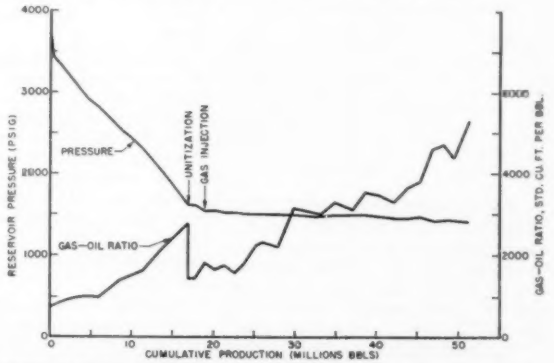
$A+B$	$A-B$	$-A+B$
$A \times B$	B/A	$B \times (A+B)$
$1/A \times B$	$A \times B \times (1+A)$	$A \times (A+B)$
$(A+B)/A$	$(A+B)^{1/2}$	$(B/A)^{1/2}$
B^2	B^3	$1/B^2$
A^2/B	$(A+B)/C$	$A \times B \times C$

If two of the 941 memory units are used, forty 10-digit numbers with sign may be stored electrically in the machine available for instant call. Additional numbers may be stored in the

(Continued on page 412)



STRATIFICATION also affects water-flood performance. Its effect in this pool will be more than 100 million barrels. Fig. 4.



RESERVOIR CONTROL has nearly doubled the production from Schuler-Jones pool, in southwestern Arkansas. Fig. 5.

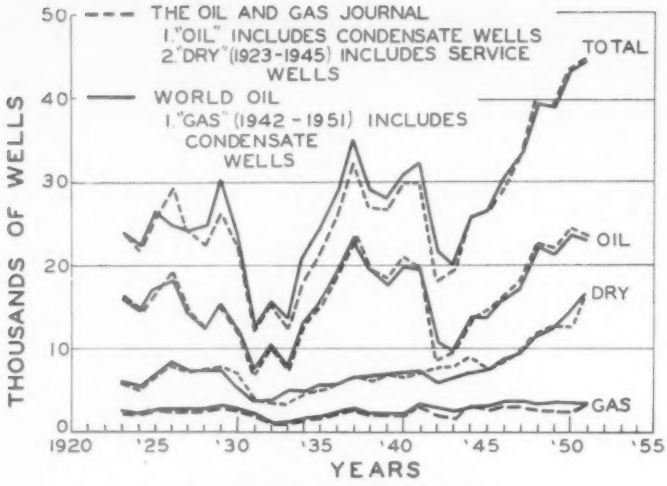


Fig. 1—Wells drilled annually in United States.

What's the Outlook for Oil-Country Tubular Goods?

New mills, operation of existing facilities at capacity, will meet needs for next 10 years, this author believes

by R. C. Zell*

WITH eight companies currently producing oil-country tubular goods, five seamless, two electric-weld, and one lap-weld mills, have a maximum capacity under ideal conditions of approximately 1,850,000 tons annually.

OIL-COUNTRY TUBULAR PRODUCTION
(From American Iron and Steel Institute)

All mills	Tons
1947	1,410,309
1948	1,607,131
1949	1,414,104
1950	1,746,979
1951	1,897,751
1952*	768,888

*Six months.

Although there is some flexibility as to the size ranges which can be produced, there are certain limiting factors which keep mills from producing greater footage from the foregoing tonnage. Generally speaking, when we talk of a steel mill's ability to produce oil-country tubular goods, we are talking about two production lines on which the size range is fairly well fixed. Mills which are used to produce the range of sizes 2⅜ through 5½-in. outside diameter cannot be used for 7-in. and larger diameter pipe; and, conversely, the small sizes cannot be economically manufactured on the facilities used to turn out the large sizes of tubular goods.

A corollary in the petroleum industry would be the use of a rotary rig designed to drill to depths of 5,000 ft. being used on a 7,500-ft. or deeper hole. You might get away with it, but the wear on your equipment would not justify continuing the practice. Likewise, a hole can be drilled to 5,000 ft. with a large rig designed to drill to 12,000 or 15,000 ft., but the practice cannot be justified on a basis of sound economics.

In order for the steel industry to meet maximum design capacity of its various mills, it has been necessary to resort to what is commonly called the practice of conversion, which is the practice of obtaining steel in the form of blooms or rounds from sources other than those normally used by the manufacturer of tubular goods, then using these blooms or rounds to supplement the materials available to them from normal sources to turn out additional materials.

The question naturally arises as to how the steel industry can turn out conversion tonnage if its facilities are being used to capacity to produce regular mill tonnage. The answer is in the process by which a joint of casing is made.

Ingots are talken from the open hearth or electric furnace to the blooming mill, round mill, piercing mill, and finishing and test bench. Any interruption to any of these manufacturing facilities can cause a loss of tonnage unless arrangements are made in advance to utilize facilities available at other mills.

Texas Mill

An example of this is the planning being done by a mill which is being installed in Texas. Operators do not plan to be in fully integrated operation until the second quarter of 1953, because of a setback in delivery of rolling-mill equipment. Pending completion of installation of rolling-mill equipment, the mill will be in production of ingots which may be taken to some other mill for rolling into skelp. Skelp is the term for sheet and plates which are trimmed to sizes and made specifically for manufacture into tubular goods.

This type of conversion can involve several mills, and although the foregoing example shows what can happen at an electric-weld mill, similar conditions exist at seamless mills where other forms of conversion involve the purchase of ingots, blooms, and rounds with a subsequent arrangement for blooming and round-mill facilities as well as piercing and finishing time.

If the oil industry in cooperation with the steel industry had not established rather rigid specifications for the manufacture and inspection of oil-country tubular goods, as well as performance standards, a great deal of tonnage would have been manufactured which would not have been suitable for casing wells. Thanks to A.P.I. standards, this has not been the case.

The foregoing illustrates the effort being made by the domestic steel industry to supply our requirements of oil-country tubular products; and the manner in which the oil-industry men in PAD have worked with the steel-industry men in the NPA to accomplish this intricate scheduling of steel production is worthy of commendation.

In addition to the aforementioned, 1,850,000 tons is currently being pro-

*Union Oil Co. of California, Los Angeles. Presented at thirty-second annual A.P.I. meeting, Chicago.

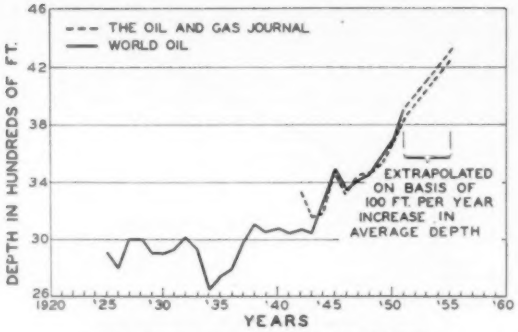

THE OIL AND GAS JOURNAL
WORLD OIL
DEPTH IN HUNDREDS OF FT.
EXTRAPOLATED ON BASIS OF 100 FT. PER YEAR INCREASE IN AVERAGE DEPTH
YEARS

Fig. 2—Average well depth in the United States.

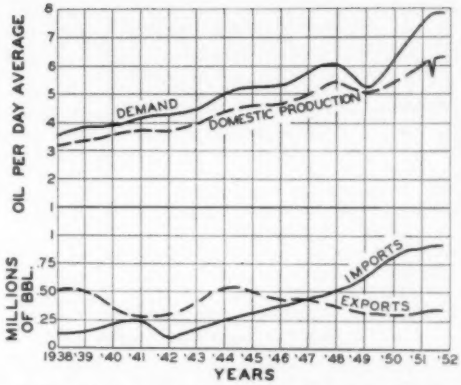


Fig. 4—Demand and domestic production daily average figures by years.

duced, there will come into production during 1953 some additional seamless and electric-weld production in the size ranges of 2⅜-in. o.d. through 10¾-in. o.d. sizes for which there is the greatest demand. This tonnage could amount to 290,000 tons for 1953 if all mills go on production as scheduled, and if rated capacity is obtained without too much loss of tonnage during the initial breaking-in period.

These mills with their rated capacities are scheduled to be placed in operation as follows:

Mill No. 1: First quarter 1953—13,500 tons per month.

Mill No. 2: Second quarter 1953—29,000 tons per month.

Mill No. 3: Late third quarter 1953—12,500 tons per month.

During 1954 and subsequent years the facilities added in 1953 could contribute 660,000 tons per year, provided the mills are operated to their rated maximum capacity on oil-country tubular goods. Economics may dictate the manufacture of line pipe, mechanical pressure tubing, etc., in addition to oil-country tubular goods. Under these conditions a minimum of 400,000 tons should be produced in these new mills.

In addition to the mills which will be put on production during 1953, several manufacturers are considering plans for additional facilities to manufacture oil-country tubular goods and it is to be expected that at least one of these mills will develop from the drawing board to an actuality during 1954.

Additional production can be obtained from existing facilities by modernization of blast furnaces and im-

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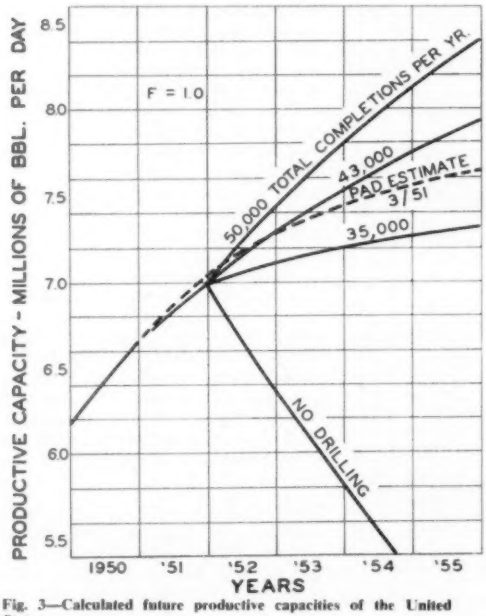


Fig. 3—Calculated future productive capacities of the United States.

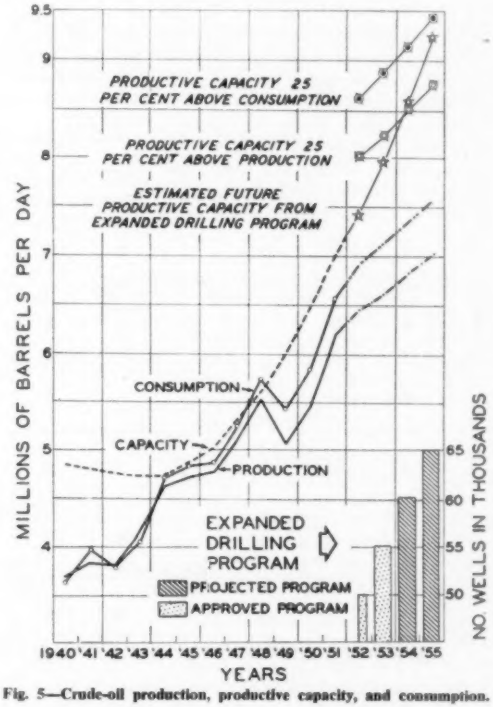


Fig. 5—Crude-oil production, productive capacity, and consumption.

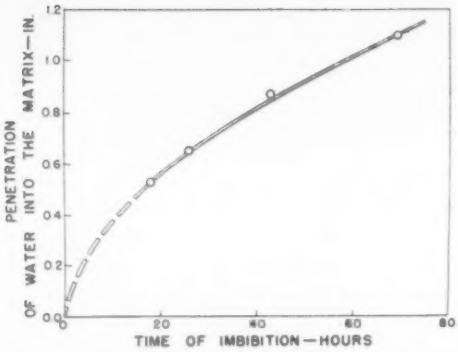


Fig. 1—Penetration of water in Spraberry matrix in laboratory imbibition-displacement experiment.

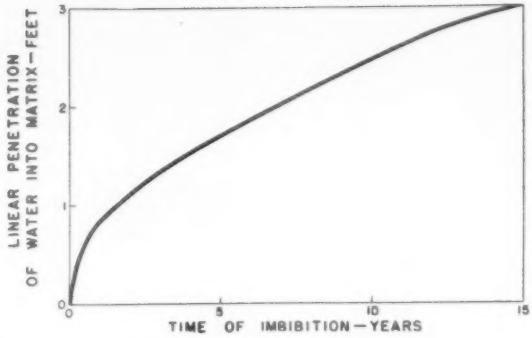


Fig. 2—Estimated linear advance of the water front with imbibition under Spraberry reservoir conditions.

Water-Imbibition Displacement . . . Can It Release Reluctant Spraberry Oil?

Laboratory tests indicate that the process should substantially increase recoveries

by E. R. Brownscombe* and A. B. Dyes*

ALTHOUGH the Spraberry trend contains very large quantities of oil, the rapid decline of the well productivity attended by rising gas-oil ratios has been a cause of considerable concern to operators there. The estimated recovery, which is about 10 per cent of the oil in place, indicates the necessity of some alternate method of production which will give a higher recovery.

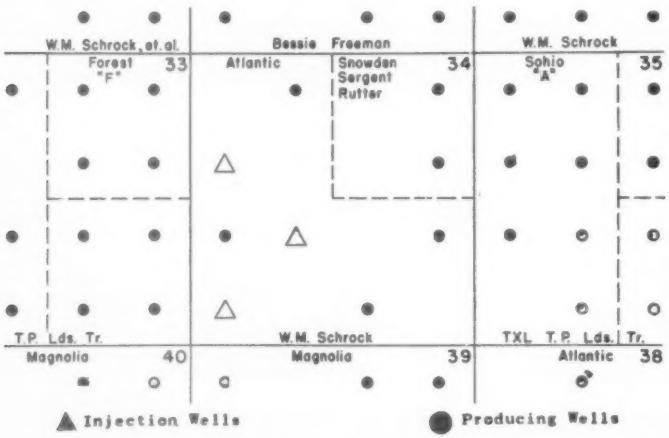
Conventional water flooding is generally recognized to be impractical. This is because most of the oil is stored in a very tight matrix, whereas, most of the permeability is the result of a large number of fractures.[1,2,3,4] Thus, conventional water flooding with water flowing from the injection well through the matrix to the producing well is out of the question. Channeling would be extremely serious. It would be even more serious for gas injection.

Inasmuch as channeling is inevitable, the thought has occurred that the fracture system provides a ready access to large areas of the matrix; and that, if the fractures were filled with water, natural imbibition, or the tendency of water to soak into rock, might provide an economic means for producing oil from the Spraberry.

Early qualitative tests gave support to the idea when it was found that pieces of Spraberry matrix saturated with oil and placed in a beaker of water rapidly formed droplets of oil over the rock surface. This indicated that the water was imbibing into the rock and the oil was oozing out of the same surface into which the water was entering.

Concept of process . . . In the field the process would be somewhat as follows: There would be a set of injection wells and of producing wells, perhaps in a five-spot or nine-spot pattern. Near the injection wells the frac-

*The Atlantic Refining Co., Dallas, Tex.
Presented at thirty-second annual A.P.I. meeting, Chicago.



In Fig. 2, the laboratory data of Fig. 1 are adjusted to take into account the difference in reservoir and laboratory oil viscosities and the presence of free gas and connate water.

tures would be well filled with water. This water would be soaking into the matrix causing oil to flow into the fractures and to be carried on to the production wells. Perhaps the process could be visualized a little more clearly in terms of a hypothetical single fracture in which water is injected at one end and production is taken from the other. As the injected water flows toward the producing end, it is soaking into the matrix and releasing oil which takes its place in the flow stream.

If the rate of natural imbibition into the matrix is greater than the injection rate, all of the water will soak into the matrix and only oil will reach the producing end of the fractures. As the process continues, the natural-imbibition rate declines, because of the longer paths of invasion and because of complete invasion of the matrix where fractures are close. As a consequence, water must travel greater distances from the injection well before being completely imbibed. Eventually water reaches the producing wells. At this point, water production starts and the water-oil ratio rises as depletion is approached. Any water injected above the rate of natural imbibition will be produced; hence the water-oil ratio is a function both of the rate of water injection and of the natural-imbibition rate. This differs from conventional water flooding in which the water-oil ratio is determined by the degree of depletion and not by the rate of injection (in the absence of formation breakdown).

After water production begins, it may be desirable to increase the injection rate substantially, hence the percentage of water in the fractures, in order to increase the area of contact between the matrix and the water in the fractures. Although this will increase the produced water-oil ratio, it may also be expected to increase the oil-production rate and may extend the economic life of the well.

Thus, some of the important variables in the imbibition displacement process appear to be:

1. The matrix must show preference for wetting by water so that it will imbibe water causing the oil to be displaced from it.

2. The fracture spacing must be sufficiently close that the area provided for water, imbibing at the natural rate, is large enough to give an economic rate of production from the reservoir.

3. The displacement efficiency by natural imbibition must be good enough to give desirable ultimate oil recovery.

TABLE 1—OIL RECOVERY FROM LABORATORY TESTS OF WATER-IMBIBITION DISPLACEMENT IN UPPER SPRABERRY MATRIX

Core No.	Oil recovery per cent of initial oil in place	Time of imbibition days	Total porosity (per cent)	Air permeability (md.)	Interstitial water saturation (per cent)	Remarks
1	28.5	7	5.63		28.0	
2	18.8	7	6.34		35.9	
3	27.8	7	9.43		51.0	
4	31.0	7	11.00		13.5	Plates
5	19.5	7	11.40		12.3	1 x 0.75 x 0.25 in.
6	35.5	7	11.85		5.6	
7	40.7	7	12.38		44.6	Imbibition proceeding
8	40.3	7	12.66		27.1	from all sides
9	42.5	7	13.34		27.5	
10	31.6	7	13.35		60.5	
11	39.7	7	13.95		35.1	
12	66.9	4	11.62		13.3	Plates
13	54.6	4	11.95		12.6	1 x 0.75 x 0.25 in.
14	50.0	4	12.80		38.4	
15	54.7	4	12.91		35.1	Imbitation into 4
16	46.3	4	13.27		32.1	edges only
17	59.2	4	13.68		28.2	(¼ in. thick)
18	61.9	4	14.00		29.4	
19	47.1	4	14.40		31.9	
20	36.0	2	12.38		44.6	Plates
21	29.6	2	13.34		27.5	1 x 0.75 x 0.25 in.
						Imbibition into 2 short edges (¼ in. thick)
22	7.0	7	8.03	0.34	45.7	
23	24.0	7	8.61	0.25	41.2	
24	36.7	7	8.65	0.37	46.7	
25	55.2	7	9.23	0.15	62.5	
26	0	7	9.7	0.50	35.9	
27	26.2	7	11.4	0.29	63.3	
28	21.0	7	11.7	0.65	26.4	Core plugs
29	13.8	7	11.8	0.93	38.5	0.9-in. diameter
30	34.5	7	11.9	0.56	48.9	1 in. long.
31	0	7	12.1	4.9	21.4	
32	0	7	12.1	1.6	30.7	Imbibition into
33	17.1	7	12.4	1.50	27.4	the two faces
34	24.9	7	12.6	0.77	60.7	
35	16.4	7	12.8	3.3	24.4	
36	18.1	7	12.9	1.00	32.5	
37	21.3	7	13.1	0.58	37.2	
38	13.8	7	13.3	1.2	38.2	
39	15.7	7	13.7	0.96	37.6	
Average:	31					

Laboratory studies . . . As mentioned previously, the simple test of dropping oil-saturated Spraberry cores into a beaker of water demonstrated that the Spraberry matrix imbibes water readily in the laboratory. To provide quantitative data on the imbibition process, flat plates about ¼ in. thick were cut from upper Spraberry cores of the Driver area. These were saturated with X-ray opaque phenyl iodide. This material has wetting properties similar to oil and provides the X-ray absorbing medium necessary to follow the rate of advance of the water by means of periodic X-ray shadowgraphs.[5]

The plates were sealed on top and bottom with an impermeable plastic coating such that imbibition would proceed only from the edges to simulate water being in contact with a section of matrix rock. These plates were permitted to imbibe water freely into the open edges and periodic X-ray shadowgraphs recorded the position of the water front.

In general, tight cores (those of small pore size) give lower rates of imbibition than do loose cores because, although the imbibition force increases as the pore size decreases, the permeability is proportional to the square of the pore size. Thus, over-all it might be expected that the rate of imbibition would be proportional to the square root of the permeability (assuming that the contact angle and the geometry of the pores are constant).[6]

Penetration rate substantial . . . The data in Table 1 suggests that in the Spraberry some of the tighter cores imbibed faster than the looser cores, possibly because of an unusual variation in pore geometry with permeability. In spite of the fact that Spraberry cores are very tight, the rate of penetration in the Spraberry as shown in Fig. 1, is substantial. Theoretical considerations based on a constant average saturation behind the in-

(Continued on page 377)

EVAPORATION LOSS OF PETROLEUM

. . . from storage tanks

. . . A symposium*

Over a period of time much petroleum can be lost by evaporation. This not only represents loss of valuable product, but the vapors constitute a definite safety hazard in the area of the storage tank. By proper selection and operation of storage tanks, evaporation losses may be kept to a minimum. This three-part symposium brings the latest information on this subject to the operator. In Part 1, basic theory and mechanism are discussed. In Part 2, evaporation from cone-roof tanks is considered, and in Part 3, evaporation from conservation-type tanks is discussed.

In order to point out in the usual interrelation of the many variables affecting evaporation losses, and to indicate the mechanisms by which such losses occur, it may be well to follow the sequence of events through "24 hours in the life of an oil-storage tank."

Assume, for purposes of illustration, a steel tank which has a tight fixed roof with two open-vent connections near the edge of the roof but 180°

*Adopted from a symposium presented at the thirty-second annual A.P.I. meeting, Chicago, 1952.

1. Basic Theory and Mechanism

By Group A Subcommittee, A.P.I. Division of Marketing

THERE are wide variations between theory and practice in evaporation-loss work. Reasons for these variations lie in the evaluation of the effects of the various pertinent factors such as temperature changes, vapor pressure, wind, vapor-space volume, tank size and proportions, and time.

The empirical approach must then be used to establish simple and accurate equations for evaporation losses.

A new series of vapor-pressure charts is herein made available. These charts are more accurate than those formerly used, in that they differentiate between different grades of gasolines and crude oils.

Members of Group "A" Subcommittee include H. C. Packard (chairman), Shell Oil Co., New York; C. C. Ashley (vice chairman), Redwood City, Calif.; C. H. Bunn, Jr., Standard Oil Development Co., Linden, N. J.; G. P. Bunn, Phillips Petroleum Co., Bartlesville, Okla.; J. H. Field, Sohio Petroleum Co., Oklahoma City; P. E. Frank, Sinclair Refining Co., New York; H. W. Harts, Warren Petroleum Corp., Tulsa; C. T. Hellsten, Cities Service Co., New York; O. W. Johnson, Standard Oil Co. of California, San Francisco; D. L. Katz, University of Michigan, Ann Arbor; P. J. Milo, The Texas Co., New York; H. S. Mount, Sun Oil Co., Philadelphia; A. H. Newberg, Service Pipe Line Co., Tulsa; H. L. O'Brien, Graver Tank & Manufacturing Co., East Chicago, Ind.; F. L. Plummer, Hammond Iron Works, Warren, Pa.; N. L. Smith, Missouri School of Mines and Metallurgy, Rolla; J. H. Wiggins, General American Transportation Co., Chicago; and I. L. Wissmiller, Chicago Bridge & Iron Co., Chicago.

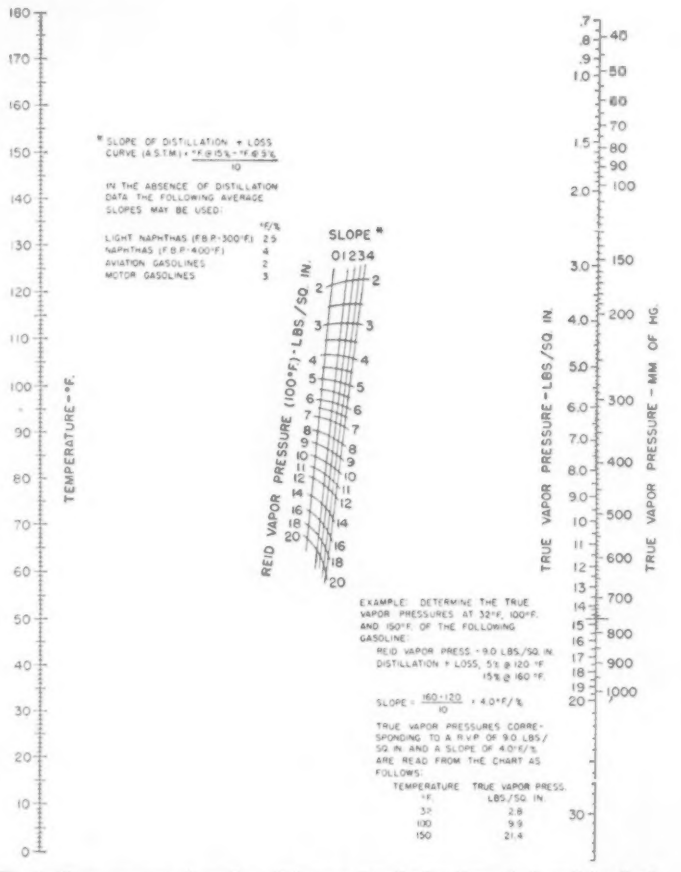

TEMPERATURE - °F.
REID VAPOR PRESSURE (100°F) - LBS./SQ. IN.
TRUE VAPOR PRESSURE - LBS./SQ. IN.
TRUE VAPOR PRESSURE - MM OF HG.
SLOPE OF DISTILLATION + LOSS CURVE (A.S.T.M.) = °F @ 5% - °F @ 95% / 10
IN THE ABSENCE OF DISTILLATION DATA THE FOLLOWING AVERAGE SLOPES MAY BE USED:
°F/%
LIGHT NAPHTHAS (F.B.P. 300°F) 2.5
NAPHTHAS (F.B.P. 400°F) 4
AVIATION GASOLINES 2
MOTOR GASOLINES 3
SLOPE °F/%
EXAMPLE: DETERMINE THE TRUE VAPOR PRESSURES AT 32°F, 100°F, AND 150°F. OF THE FOLLOWING GASOLINE:
REID VAPOR PRESS. = 9.0 LBS./SQ. IN.
DISTILLATION + LOSS, 5% @ 120 °F, 95% @ 160 °F.
SLOPE = (160 - 120) / 10 = 4.0°F/%
TRUE VAPOR PRESSURES CORRESPONDING TO A R.V.P. OF 9.0 LBS./SQ. IN. AND A SLOPE OF 4.0°F/%. ARE READ FROM THE CHART AS FOLLOWS:
TEMPERATURE °F.
TRUE VAPOR PRESS. LBS./SQ. IN.
32 2.8
100 9.9
150 21.4

Fig. 1—Vapor pressure of gasolines. Reference: Coordinating Research Council handbook, pg. 244-254 (1946).

apart, partly filled with a volatile oil uniformly mixed.

Assume also that the diurnal cycle starts at the 0500 hour, a time which has been established by test as being, on the average, one when temperature conditions within and around the tank are most nearly uniform and stable.

Initial conditions . . . At 0500 hour the following conditions may be expected:

1. Average atmospheric temperature is the same as the average temperature in the tank vapor space.

2. There is no flow, either in or out, through the tank vents.

3. Temperatures throughout the body of the oil are quite uniform, and appreciably higher than the outside atmosphere. Consequently, heat is being lost through the tank shell, thus creating a layer of cooler oil along the shell, with mild convection currents carrying this cooler oil downward toward the tank bottom around the shell and inducing a rising flow over the inner areas of the oil body and across the oil surface to replace the downward-moving cooler oil.

4. Temperature gradients exist in the vapor space, with the lowest temperatures at the roof and the highest at the oil surface. There are mild convection currents in the vapor space which are mixing the richer vapors from near the oil surface with the leaner vapors in the upper parts of the vapor space, thus tending to create a uniform vapor concentration throughout.

5. There is no wind.

Day-time changes . . . From 0500 hour until sunrise there is a slight increase in atmospheric temperature, insufficient to have appreciable effect on tank conditions. After sunrise, in a clear sky, conditions change rapidly due to the advent of direct solar heat; and the following conditions become typical:

1. Atmospheric temperatures are rising, and heat is delivered to the tank from the atmosphere by conduction.

2. Direct solar heat (radiant) warms the tank shell on the sunny side, and on the roof, with the following effects:

(a) Below the liquid level, the oil next to the shell is heated above the temperature of the remainder of the oil body—reversing the previous convection flow in that region, and causing a layer of warmer oil to rise along the shell and to spread over the oil surface. This increases the vapor pressure at the oil surface, thus increasing the vapor concentration at that point and transferring some heat to the vapor space.

(b) Above the liquid level on the shell, and on the roof, the heat is transferred through the metal and into the vapor by conduction and convection, and to the liquid surface by nonluminous radiation. These transfers of heat increase the average temperature in the vapor space, and increase further the oil-surface temperature with corresponding increase in surface vapor pressure.

3. The contents of the vapor space, expanding with increased temperature and higher oil-surface vapor pressure, begin to discharge through the tank vents.

4. Frequently wind rises. Depending on direction and temperature, it may provide heat input to, or remove heat from, the tank. However, with open tank vents, the most important effect of wind is to increase vapor loss by "windage."

As the day progresses, and assuming that skies remain clear, all temperatures continue to rise, and the rate of flow of vapors from the tank vents increases. At some time in the latter part of the day the rise in atmospheric temperature ends.

Temperature drops . . . Although direct solar-heat input continues until sunset, it is at a diminishing rate as the sun approaches the horizon. With decreased heat input, tank-metal temperatures begin to fall—until they are essentially the same as those of the vapor or liquid in contact with the metal. At this point heat input to the tank ends and, as atmospheric temperature continues to drop, heat loss from the tank to the atmosphere begins. In this period:

1. The rate of vapor outflow from the tank vents, which has been decreasing since atmospheric temperatures began falling in the late afternoon, falls to zero; and, as temperatures continue to fall, it changes to an inflow of air as the vapor-air mixture in the tank contracts.

2. Convection currents in both the vapor space and the oil body reverse their directions of flow compared to what they were during the time that heat was entering the tank. In the vapor space these currents tend to mix the fresh air which enters through the vents with the vapor-air mixture al-

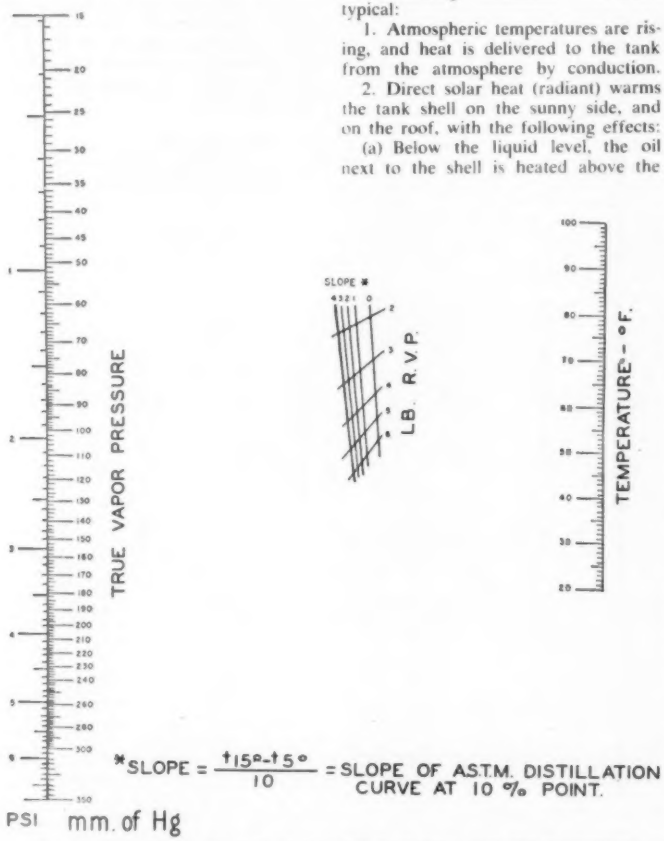


Fig. 2—Vapor pressure of gasolines; range, 2 to 6 psi. R.v.p. Ref., C.R.C. handbook.

ready in the tank and, in the liquid, they tend to equalize temperatures throughout the oil body.

3. Wind, which usually will persist through early evening, may continue to cause windage losses even though the net flow through the vents is inward.

Night-time changes . . . During the late hours of the evening and until the early hours of the morning, atmospheric temperatures will continue to drop—with heat loss from the tank continuing, and causing further contraction in the vapor space and reduction of oil-surface temperature. Tank-roof temperatures may drop appreciably below atmospheric because of radiation to the clear, cold sky. Air inflow through the vents continues under the influence of thermal contraction of the vapor space, and of condensation of vapor, due to temperature drop and reduction of oil-surface vapor pressure.

Presently atmospheric temperature reaches its minimum value for the day, and remains relatively stable for a period of several hours. Conditions in the tank approach greater uniformity during this period; the average temperature in the vapor space approaches atmospheric; wind ceases; and flow through vents in either direction becomes negligible.

It is the 0500 hour again, and the tank is about to undergo the changes of another diurnal cycle. In general, it will follow the pattern of the preceding 24 hours; but, in detail, it will be different, because atmospheric and weather conditions never follow exactly the same pattern on succeeding days, and operating requirements may call for oil movements into or out of the tank.

In the foregoing discussion, conditions of clear skies, steady weather, and standing storage were assumed for simplicity in order to outline the basic diurnal cycle to which oil tanks are subjected. It should be obvious without detailed discussion that all of those natural phenomena classed broadly as "weather" can affect the details of the diurnal cycle. For example, fog, haze, or clouds will reduce atmospheric temperatures and decrease direct solar-heat input; or a summer thunderstorm quickly can change tank heat input to heat loss, and vapor outflow to air inflow.

Effect of oil movements . . . Oil movements into or out of a tank will superimpose their effects on the diurnal thermal cycle.

Oil inflow will:

1. Increase vapor outflow during the period of thermal out-breathing.
2. Cause vapor outflow when there is no thermal breathing.
3. Decrease or offset air inflow, or cause some vapor outflow, during periods of thermal in-breathing.

Oil outflow will:

1. Decrease or offset vapor outflow, or cause some air inflow, during periods of thermal out-breathing.
2. Cause air inflow when there is no thermal breathing.
3. Increase air inflow during periods of thermal in-breathing.

Temperature Changes

The tank temperature changes of particular interest in this problem are those which result during the day from heat input by solar radiation and by high atmospheric temperatures, and those which result during the night from heat loss to the atmosphere and by nonluminous radiation into space.

From a long-time viewpoint, the sensible heat of inflowing liquid streams is of secondary importance, as such sources of heat are susceptible to a degree of control by careful attention to operating practices.

Significant effects of heat input or loss whose magnitude may be indicated by extent of temperature change are:

1. In the vapor space: volumetric expansion or contraction, causing flow through the tank vents. A temperature drop when the vapor space is at or near the saturation point may cause vapor condensation, with further volumetric contraction.

2. In the liquid space: change of surface vapor pressure, resulting in vaporization of liquid or condensation of vapor. Vaporization increases volumetric expansion of the vapor space, whereas condensation causes contraction.

All of these effects point to the fact that wide temperature variations will increase the volumes of vapor or air which flow through the tank vents and, conversely, that anything which can be done to minimize temperature changes within the tank will reduce such flow.

To reduce heat loss . . . There are a number of things which can be done to minimize heat transfer, with re-

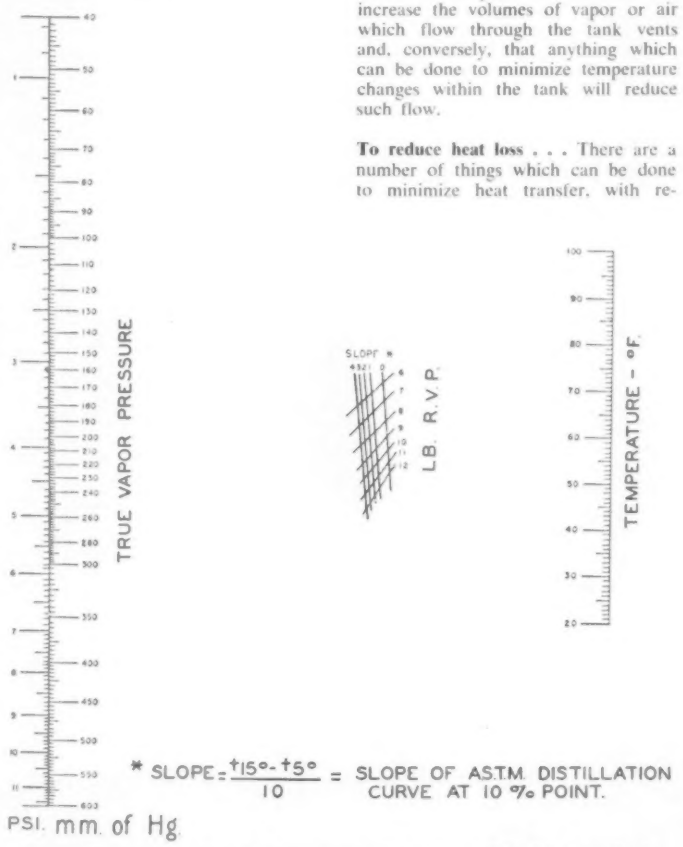


Fig. 3—Vapor pressure of gasolines; range, 6 to 12 psi. R.v.p. Ref., C.R.C. handbook.

sultant temperature change, as follows:

1. Painting the tank with white paint of the so-called "self-cleaning" type: There is ample evidence that this kind of paint gives the lowest heat absorption and greatest reflectivity of any of the common tank paints.

2. Applying heat insulation to the tank roof: This will reduce heat input through the roof, thus decreasing temperature change in the vapor space and heat radiated to the oil surface. However, this will not affect heat input through the shell which, according to several investigators, is the principal source of heat input to the liquid body, and which may be a significant source of heat input to the vapor space when the tank is only partly filled.

3. Water sprays on the roof, or the use of a water-deck roof, will produce results similar to roof insulation.

4. Installation of pressure and vacuum breather valves on the tank vents, although not actually a means of limiting temperature change, produces a similar result of reducing flow through the vents by requiring that a low but definite pressure be developed in the tank before out-breathing of vapor will occur, and by requiring that a slight degree of vacuum be developed before in-breathing of air takes place. A more important function of these valves is the complete elimination of windage losses.

Vapor Pressure

True vapor pressure will be recognized readily as the primary cause of evaporation loss, for it is the characteristic of the stored oil which determines the amount of oil which will vaporize into the space above the liquid. The amount vaporized will vary in direct proportion to the relation between partial pressure of the vapor at the oil surface and the total pressure in the vapor space.

It is important to note that the controlling vapor pressure is that of the oil surface—presumably a layer of oil of molecular thickness—and that the temperature which, for any given oil, produces this vapor pressure is also that of the oil surface. Thus, in order to attempt evaluation of the effects of vapor pressure on evaporation losses, it is necessary to establish relationships between true vapor pressure and temperature for all grades of oil. This is done best by graphical presentation.

A vapor-pressure chart, plotted on rectangular coordinates, which has received rather wide acceptance in the industry for some time shows a marked irregularity between the lines representing oils classified as 12-lb. Reid and 14-lb. Reid. These two lines, which logically should be parallel, show a divergence with increasing temperature, which is believed to be indicative of error.

New charts . . . Accordingly, this paper offers for the consideration of the industry a series of new vapor-pressure charts (Figs. 1 through 5) which are of the nomographic or alignment type. Figs. 1 through 4 recognize more recent evaluations which indicate that, for gasolines, the relationship between Reid vapor pressure and true vapor pressure will vary in some degree depending upon the low-temperature volatility characteristics of the gasoline under consideration.

The slope of the A.S.T.M. distillation (plus loss) curve at the 10 per cent point provides a criterion for this variation, as shown in the illustrations.

Fig. 5 is the first of a new series of charts for crude oils (currently in process of preparation) which will recognize that the relationship between true vapor pressure and Reid vapor pressure for crude oils differs from the relationship for gasolines, and also differs between grades and types of crude oil. The widely varying composition of crude oils makes any general evaluations of them by the use of charts less precise than in the case of gasolines or other stabilized materials.

Boiling may occur . . . Reference to these illustrations will show that, for oils having fairly high vapor-pressure characteristics under the Reid classification, it is possible to reach pressures essentially atmospheric and at which boiling will occur at temperatures within the range which can be reached by direct solar exposure. Such boiling will increase evaporation losses to a marked and unpredictable degree; and, as boiling involves a transfer of heat, the extent to which it will take place will depend on solar intensity and time of exposure.

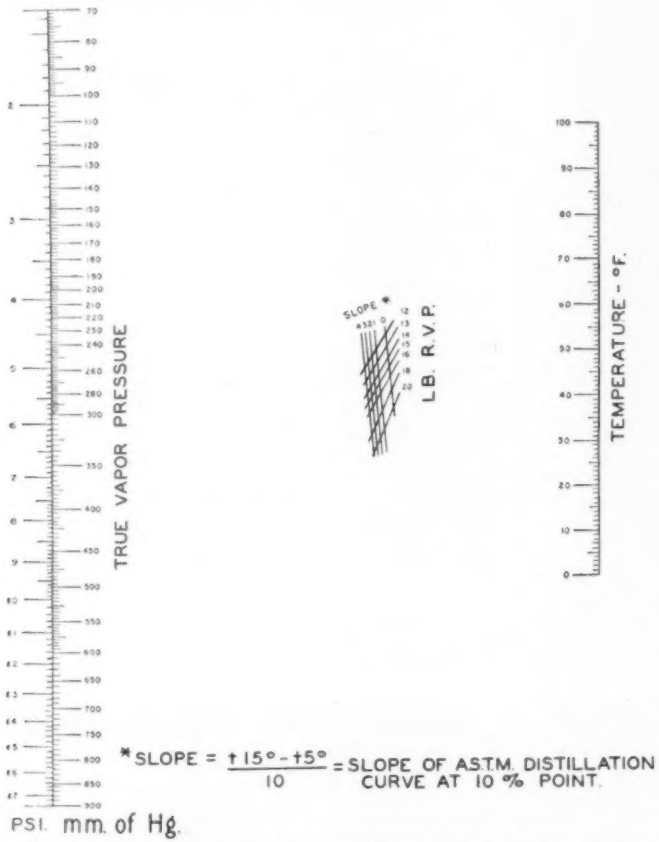


Fig. 4—Vapor pressure of gasolines; range, 12 to 20 psi. R.v.p. Ref., C.R.C. handbook.

A small amount of boiling may take place under many conditions, but the loss from boiling really becomes significant when the boiling point of the stock being stored is so low that boiling may take place as a result of heat transfer from the atmosphere.

Boiling also may occur when an oil which has been heated by some means is discharged subsequently into a tank. Occasionally the removal of process heat is incomplete, so that a stock is discharged into the tank above its boiling point. A buried pipe line used for the transfer of light products may be close to a hot fuel line, and the temperature of the light product thus may be increased abnormally. In other cases a light oil standing in a line laid aboveground may be heated by the sun.

Windage losses . . . On tanks equipped with breather valves the effects of wind are limited to the extent to which heat input to, or heat loss from, a tank is affected by wind. Previous discussion herein of wind effects was included to emphasize the desirability of avoiding multiple openings in tank roofs, either in the form of intentional vent openings or as leaks in a roof which is either corroded or not of gastight construction.

Multiple open vents are particularly objectionable, but a form of windage can occur with but one open vent. Gusts and other wind variations can cause small, rapid pressure fluctuations at a single vent, thus producing inflow and outflow in "puffs" which, although small in individual volume, become large in the aggregate and can constitute serious losses.

Vapor-Space Volume

In any given tank with a fixed roof, vapor-space volume is at a minimum when the tank is full, and at a maximum when the tank is empty—with an infinite number of possible variations between. If during any period of temperature change in a vapor space the temperature were at all times uniform throughout the vapor space, the volume flowing through the tank vents would be proportional to the vapor-space volume.

Experience shows, however, that the time interval between successive phases of the daily tank-breathing cycle is insufficient to establish uniform conditions throughout a vapor space except in very small tanks, as heat transfer from or to the tank metal by conduction and convection is a relatively slow process. Thus the average temperature in the vapor space will follow tank-metal temperature more closely when the vapor space is small (at high liquid level) than it will when the vapor space is large (at low liquid level.)

Consequently, flow through the vents will represent a greater proportion of the vapor-space volume at high liquid level than at low liquid level for a given condition of temperature change to which the tank may be exposed.

Obviously, at a given temperature, more liquid will evaporate into a large space than into a small one. Also, in a given tank, there will be a different percentage of evaporation in the two cases, and the vapor pressure of the remaining liquid will be somewhat lower in the case where there is the larger percentage of evaporation. For this reason the vapor pressure and the maximum possible vapor concentration will depend to some extent upon the percentage filling of the tank.

Vapor uniformity . . . A further effect of vapor-space volume on the magnitude of evaporation losses comes from the influence which vertical depth of the vapor space has on the degree to which uniformity of vapor concentration in the air-vapor mixture may be established within the time limits of a daily cycle.

Assume that in-breathing has just ceased, leaving a volume of fresh air with no vapor content in the upper part of the vapor space. At the lowest level of the vapor space, at the liquid surface, the vapor concentration probably is at the saturation point. Between these two levels there is a gradual change of vapor concentration, but the physical phenomena of diffusion and convection are operating to establish uniform concentration throughout the vapor space.

These processes require appreciable time, however, and it has been found that the time available for their opera-

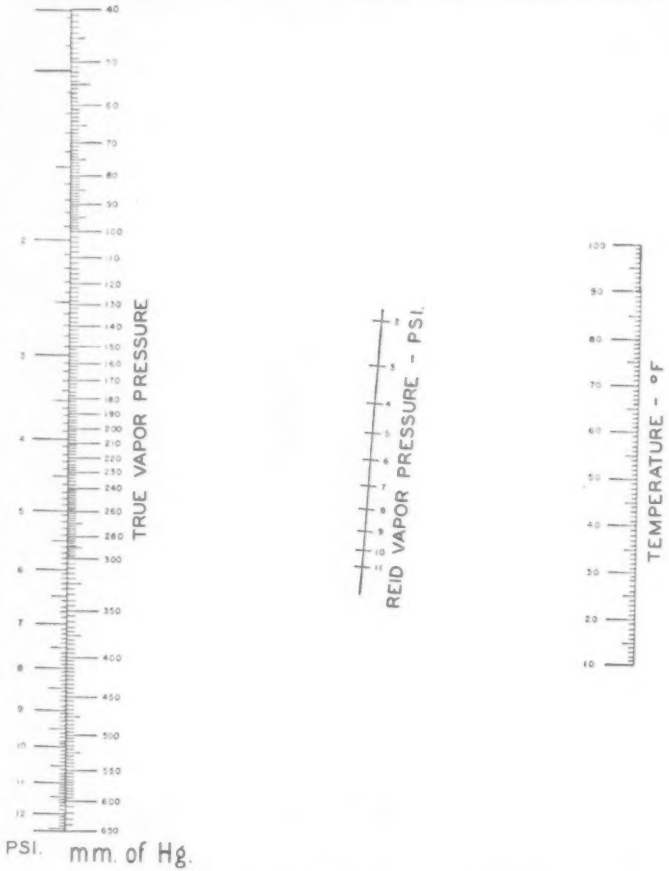
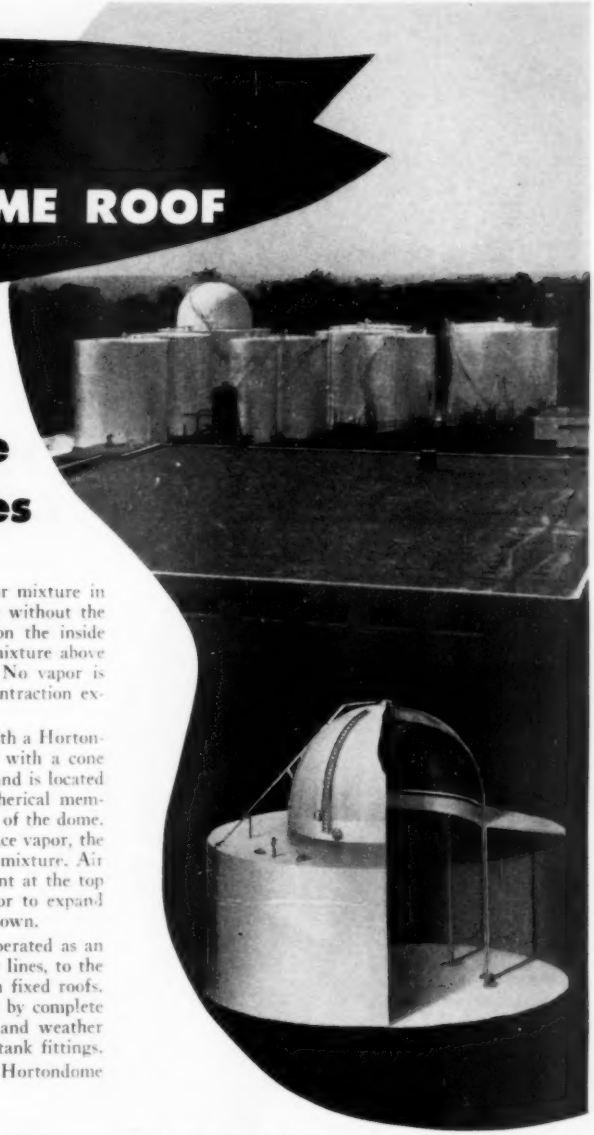


Fig. 5—Vapor pressure of crudes. Ref., C.R.C. handbook.

THE HORTONDOME ROOF

to reduce standing storage evaporation losses



The Hortondome Roof allows the air-vapor mixture in a standing storage tank to expand and contract without the usual evaporation loss. A flexible membrane on the inside of the dome moves up and down as air-vapor mixture above the liquid in the tank expands and contracts. No vapor is vented to the atmosphere until expansion or contraction exceeds the capacity of the Hortondome Roof.

The bottom, shell and top angle of a tank with a Hortondome Roof are the same as a flat-bottom tank with a cone roof. The dome is of butt-welded construction and is located in the center of the roof. The flexible hemispherical membrane is attached by its outer edge to the bottom of the dome. As vapor is formed or filling takes place to displace vapor, the membrane rises to make room for the air-vapor mixture. Air above the membrane is forced out through a vent at the top of the dome. When conditions causing the vapor to expand are reversed, the flexible membrane goes back down.

A tank with a Hortondome Roof may be operated as an individual unit or it may be connected, by vapor lines, to the vapor spaces of one or more adjacent tanks with fixed roofs. Continuous and dependable operation is assured by complete protection of all moving parts from the wind and weather and the simplicity of the vents, gages and other tank fittings.

For further information or quotations on Hortondome Roofs, write our nearest office.

Top: Tank with Hortondome Roof and adjacent fixed-roof tanks whose vapor spaces are connected to it. Bottom: Cutaway view of Hortondome Roof showing dome and flexible membrane.

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3. BOILER WATER WITH NALCO ANTIFOAM Treatment —same water as in Photo No. 2 —now produce large bubbles without foam and pure steam ...the same results as distilled water.

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THE *Nalco* SYSTEM.

tion in each daily tank cycle is insufficient to establish uniformity. The result is that there is always a variation in vapor concentration throughout the vertical height of the vapor space, with the lowest concentration at the top.

When the vapor-space volume is small, with high liquid level, the volume of air which enters the tank during in-breathing is relatively small, and the vertical distance from the region of highly saturated vapor at the liquid surface is at a minimum. Under these conditions, the greatest possible degree of saturation of that air will occur within the cyclic time available.

When the vapor-space volume is large, with low liquid level, the volume of air which enters with each in-breathing is large, and the vertical distance above the oil surface is at a maximum, but the liquid surface area is unchanged. The combination of larger fresh-air volume, greater total vapor-space volume, and greater vertical height above the oil surface prevents the vapor concentration at the upper levels of the vapor space from reaching as high values under this latter condition as under the former.

When out-breathing resumes, it may be expected that the concentration of vapor in the air-vapor mixture flowing from the tank vents will be lower with a large vapor-space volume than with a small one.

Over-all effects . . . Combining the effects of temperature change in the vapor space and vapor concentration therein on a basis of vapor-space volume, it appears that:

1. The volume of flow through the tank vents is larger with a large vapor-space volume than with a small one, but the degree of vapor saturation in the outflowing air-vapor mixture from the larger volume is lower than from the smaller.

2. The effects of lower vapor concentration offset to some degree the potential evaporation losses due to the higher volume of flow.

It has been determined that the resultant total loss is greater from the larger vapor-space volume, but the relation to that form a smaller volume is somewhat less than directly proportional to the relative volumes.

Tank Size and Proportions

Discussions presented so far have considered only a typical fixed-roof tank of unspecified size. If evaporation-loss results are obtained on tanks of certain sizes, and if it is desired to extend those results to the prediction of possible losses from tanks of other sizes, it becomes necessary to ascertain what may be the effects of variations in tank size and proportions.

For example, if two tanks of the same capacity may be considered, one of large diameter and low height and the other of smaller diameter and greater height, it seems probable, on the basis of preceding discussions, that the lesser loss would be sustained with the latter tank.

Surface-volume ratio . . . In general, the pertinent variable appears to be the ratio of tank-surface area to tank volumetric capacity (which has been termed "hydraulic mean ratio") which decreases with increase in tank diameter, indicating that the larger tanks have fewer square feet of surface area per cubic foot of volume than do the smaller tanks. Thus the over-all rate of heat input to, or loss from, the tank contents should be less per unit of volume for the larger tanks, and lower unit loss rates might be anticipated. However, degree of filling has a very important bearing on the relationship of potential heat-transfer conditions on a tank-size basis.

Considering first heat transfer to or from the liquid body through the tank shell, it is found that, although volume varies as the diameter squared, available heat-transfer surface varies only as the diameter, and this holds regardless of the liquid height. For heat changes in the liquid, therefore, the hydraulic mean ratio should provide an index of comparison.

For the vapor space the situation is more complex. At high liquid levels very little of the tank-shell area is in contact with the vapor space, and heat transfer affecting the vapor space occurs almost entirely through the roof.

Roof area varies as the diameter squared, the same as does the vapor-space volume, which gives a constant ratio between these factors regardless of tank size. At low liquid levels, however, an appreciable proportion of the heat-transfer area may be provided by the tank shell.

Again shell area varies as the diameter, whereas volume varies as the diameter squared, so that the hydraulic mean ratio should provide an index of comparison for that portion of the heat change in the vapor space passing through the shell. Probably the over-all effect will be evaluated somewhere between the two relationships indicated.

Time

Time appears as a factor in evaporation-loss studies in two ways:

1. As related to the time sequence, or relative timing, of different phases of the daily breathing and operating cycle of a tank.

2. As it provides a basis and opportunity for averaging out the marked variations of daily or short-time occurrences into a representative pattern of over-all behavior.

The potential effects of relative timing on the magnitude of evaporation losses can be indicated by several typical examples:

1. If a period of vapor outflow follows closely after a period of air inflow, regardleess of cause, there is insufficient time for appreciable mixing of the fresh air with the air-vapor mixture already in the tank, and the vapor concentration in the outflowing stream will be low. In fact, the initial outflow may be almost entirely air. Losses are at a minimum rate under these conditions.

2. If an extended period elapses between the end of inflow and the beginning of outflow, maximum mixing of fresh air and vapor can occur, and the vapor concentration in the outflowing stream will be greater, with correspondingly greater loss rates.

3. If a short period of inflow is followed by a long period of outflow, the total outflowing volume may exceed greatly the air volume which entered during the period of inflow. All of that air will be forced from the tank, followed by a volume of air-vapor mixture which has had extended residence time in the tank and which has reached a higher degree of vapor saturation. This condition increases vapor-loss rates.

4. If a long period of inflow is followed by a short period of outflow, only a part of the air which entered will be discharged before inflow occurs again. This will leave a layer of partly mixed air and vapor in the vapor space above the more thoroughly mixed volume which was in the tank before the period of inflow began, and further inflow will add fresh air above the volume designated as "partly mixed." This creates stratification in the vapor space, which causes wide variation in loss rates depending on the length, sequence, and timing of periods of inflow to and outflow from the vapor space. It should be evident that rather complex patterns of stratification are possible, producing day-to-day variations in the loss rates which occur with the same volume of outflow, and even causing changes in loss rates during a single period of outflow.

An Evaporation-Loss "Formula"?

The factors involved in an evaluation of losses incurred through tank breathing may be stated as:

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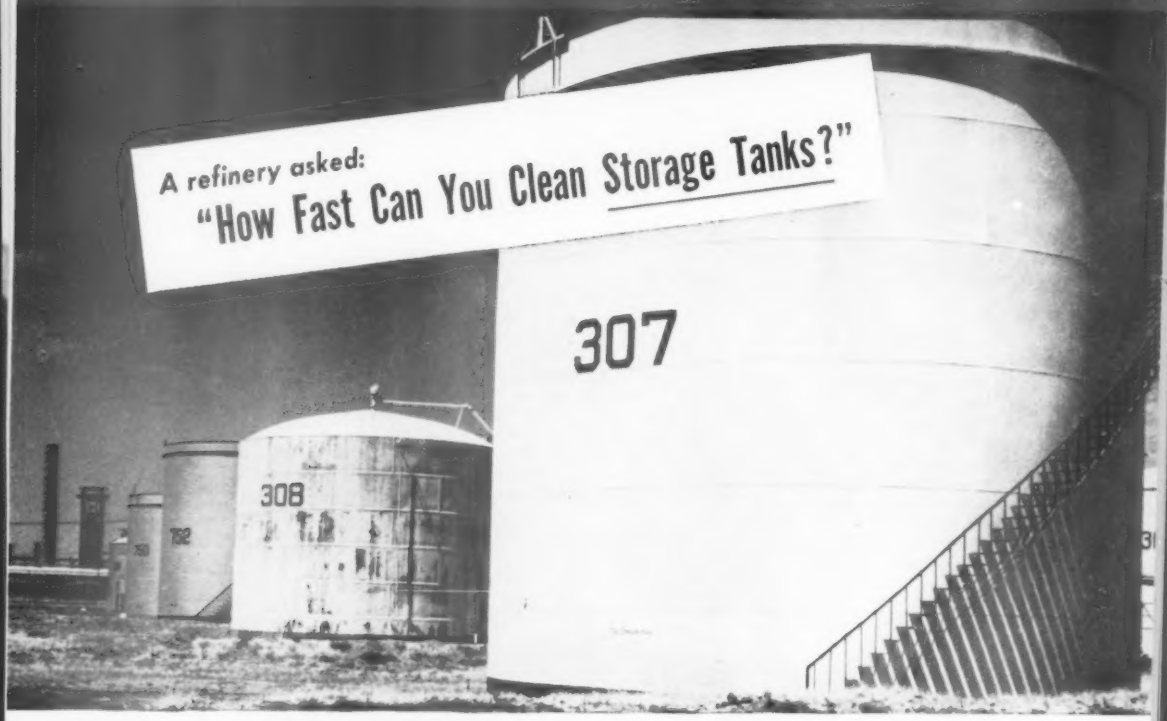

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Storage tank cleaning has been speeded up by Dowell Service! That's what many operators say about the new Dowell method, using thickened chemical solvents.

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1. Vapor-space volume as a function of liquid height or degree of filling.

2. Oil vapor pressure as a function of the Reid classification of the oil and the temperature at which it is held, which may be taken from Figs. 1 through 5.

3. Vapor-pressure change as a function of temperature change.

4. Average temperatures in the tank as a function of average daily atmospheric temperatures.

5. Temperature ranges in the tank as a function of daily atmospheric temperature ranges.

In addition, there must be an evaluation of:

1. Tank-surface conditions—involving paint, insulation, or other factors affecting heat transfer through the tank metal.

2. Tank size and proportions, expressed as a function of hydraulic mean ratio.

If an evaporation-loss formula is to be established, it must include all of these factors and the effects of their interrelation, expressed in suitable symbols. It is customary in mathematical practice to indicate the degree of variation in different factors under changing conditions by the use of coefficients or constants applied as multipliers to the different symbols. Then, to establish a workable formula, there is need for an actual evaluation of the factors involved and of the pertinent interrelationships included in the coefficients or constants.

2. Losses From Cone-Roof Tanks

By Group B Subcommittee, A.P.I. Division of Marketing

RESULTS of many tests show that breathing loss for cone-roof tanks can be predicted from an equation which takes into account these factors: tank size, outage, Reid vapor pressure, paint factor, and average temperature of the liquid body. The equation represents a composite of several methods.

Estimation of filling loss may be made by use of an equation in which the factor, vapor pressure, volume pumped in, and throughput factor, are considered.

The mechanism of breathing and the resulting theoretical breathing loss is described by the equation:

$$L = V_1 \frac{(P_1 + P_2)}{880} \times \left[\left(\frac{A+G_1-P_1}{A+G_2-P_2} \right) \left(\frac{T_2+460}{T_1+460} \right) - 1 \right] \quad (1)$$

Where:

L = gallons of gasoline lost in one breathing cycle.

G_2 = gage tank pressure at which pressure vent opens.

G_1 = gage tank pressure at which vacuum vent opens (usually negative).

A = atmospheric pressure.

P_2 = vapor pressure at maximum liquid-surface temperature, psi.

P_1 = vapor pressure at minimum liquid-surface temperature, psi.

T_2 = maximum average vapor-space temperature, °F.

T_1 = minimum average vapor-space temperature, °F.

V_2 = maximum volume of vapor space, cu. ft.

V_1 = minimum volume of vapor space, cu. ft.

The quantity within brackets represents the theoretical expansion of the air-vapor mixture expressed as a fraction of the vapor-space volume V_1. In fixed-roof tanks which have conservation vents with low settings, the value of this quantity does not usually exceed about 12 or 15 per cent, and is normally much lower. With a value of this low order, the theoretical equation for breathing loss may be expressed, with very small error, thus:

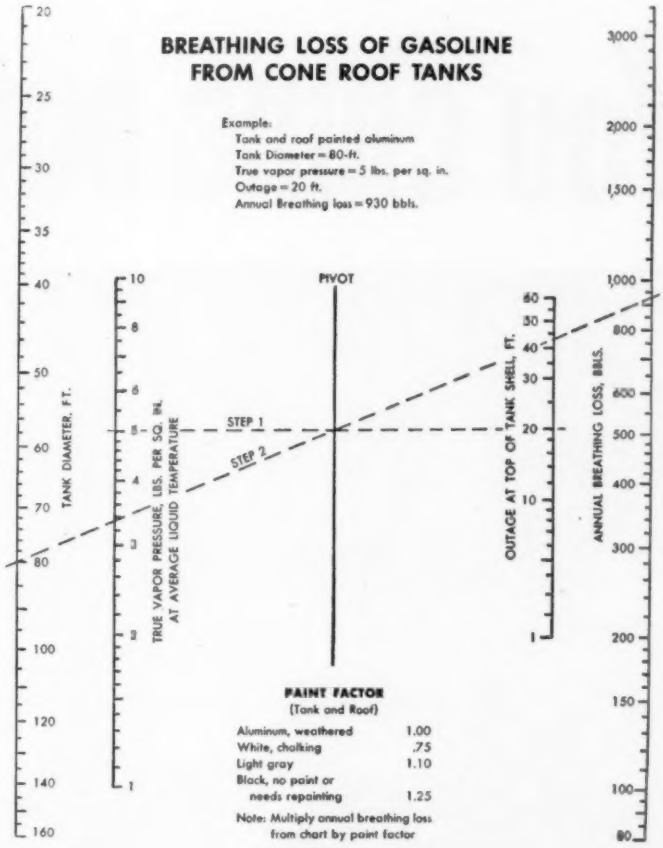
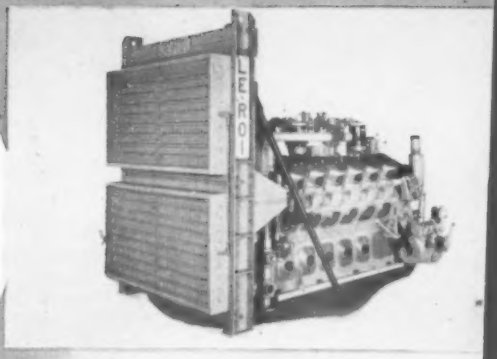

BREATHING LOSS OF GASOLINE FROM CONE ROOF TANKS
Example:
Tank and roof painted aluminum
Tank Diameter = 80-ft.
True vapor pressure = 5 lbs. per sq. in.
Outage = 20 ft.
Annual Breathing loss = 930 bbls.
TANK DIAMETER, FT.
TRUE VAPOR PRESSURE, LBS. PER SQ. IN. AT AVERAGE LIQUID TEMPERATURE
PIVOT
STEP 1
STEP 2
OUTAGE AT TOP OF TANK SHELL, FT.
ANNUAL BREATHING LOSS, BBLS.
PAINT FACTOR
(Tank and Roof)
Aluminum, weathered 1.00
White, chalking .75
Light gray 1.10
Black, no paint or needs repainting 1.25
Note: Multiply annual breathing loss from chart by paint factor

Fig. 1.

Members of Group "B" Subcommittee include L. S. Wrightsman (chairman), Humble Pipe Line Co., Houston; R. W. Bodley, Graver Tank & Manufacturing Co., East Chicago, Ind.; N. Friz, Esso Standard Oil Co., New York; O. Gerbes, Humble Oil & Refining Co., Baytown, Tex.; H. W. Harts, Warren Petroleum Corp., Tulsa; L. R. Neal, Jack Neal, Inc., San Antonio; S. S. Smith, Shell Oil Co., New York; J. H. Wiggins, General American Transportation Co., Chicago; and I. L. Wissmiller, Chicago Bridge & Iron Co., Chicago.

Le Roi 3-way partnership



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$$L = V_1 \left(\frac{P_1 + P_2}{880}\right)\left[\left(\frac{T_2 - T_1}{T_1 + 460}\right) + \left(\frac{P_2 - P_1}{A + G_2 - P_2}\right) - \left(\frac{G_2 - G_1}{A + G_2 - P_2}\right)\right] \quad (1a)$$

Meanings of terms . . . Equation 1a gives a little clearer concept of the nature of breathing losses. Each factor and term has a definite physical meaning. V_1 is the volume of the vapor space in cubic feet. This factor $\frac{P_1 + P_2}{880}$ is the theoretical vapor concentration or the number of gallons of liquid hydrocarbon contained in 1 cu. ft. of air-vapor mixture. This quantity within brackets is the total theoretical expansion expressed as a fraction of the vapor-space volume.

When the vapor-concentration factor $\frac{P_1 + P_2}{880}$ is multiplied by the vapor-space volume V_1, it gives the theoretical number of gallons contained in the vapor space. This, in turn, when multiplied by the quantity with brackets, gives the theoretical loss L, in gallons, for the breathing cycle, which is usually 1 day.

In the approximate Equation 1a the theoretical expansion is broken down into three parts. The first term $\frac{T_2 - T_1}{T_1 + 460}$, is the expansion which results from vapor-space temperature change. The second term, $\frac{P_2 - P_1}{A + G_2 - P_2}$, represents the theoretical expansion which results from additional hydrocarbon evaporating into the vapor space when rising liquid-surface temperature causes an increase of true vapor pressure. The last term, $\frac{G_2 - G_1}{A + G_2 - P_2}$, is subtracted from the other two. It represents a reduction of the total expansion which results from compression caused by increase of the tank gage pressure between the vacuum and the pressure-vent settings.

TABLE 1—ESTIMATED BREATHING LOSSES FROM CONE-ROOF TANKS—COMPARISON OF SEVERAL COMPANY METHODS

Tank size: Nominal capacity (bbl.)	Diameter (ft.)	Shell height (ft.)	Estimated breathing losses (bbl. per year) under stated conditions — Company A	B	C	D	E	F	G	H	Avg.
5,000	30	40	145	155	130	148	139	225	176	112	154
5,000	35	30	179	152	143	172	157	225	173	152	169
10,000	42½	40	290	290	262	267	280	438	321	225	297
20,000	60	40	578	530	522	550	558	828	542	449	570
55,000	100	40	1,600	1,200	1,450	1,090	1,540	1,815	1,107	1,253	1,382
67,000	100	48	1,690	1,400	1,683	1,180	1,735	2,018	1,329	1,253	1,536
80,000	120	40	2,310	1,600	2,087	1,490	2,250	2,160	1,464	1,800	1,895
125,000	150	40	3,620	2,300	3,260	2,170	3,495	2,160	2,206	2,813	2,753
150,000	150	48	3,820	2,700	3,786	2,340	3,910	2,160	2,647	2,813	3,022

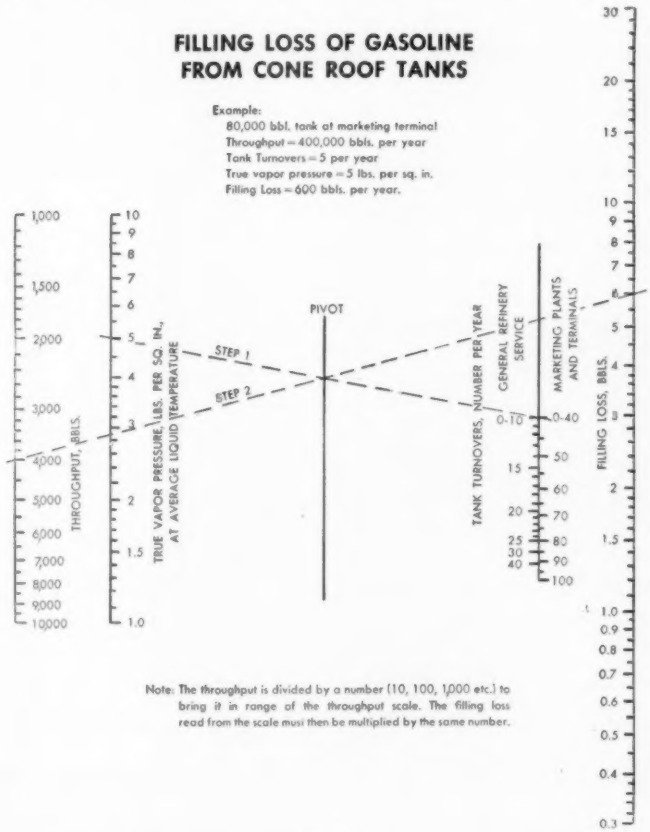
FILLING LOSS OF GASOLINE FROM CONE ROOF TANKS
Example:
80,000 bbl. tank at marketing terminal
Throughput = 400,000 bbls. per year
Tank Turnovers = 5 per year
True vapor pressure = 5 lbs. per sq. in.
Filling Loss = 600 bbls. per year.
THROUGHPUT, BBLS.
TRUE VAPOR PRESSURE, LBS. PER SQ. IN., AT AVERAGE LIQUID TEMPERATURE
PIVOT
STEP 1
STEP 2
TANK TURNOVERS, NUMBER PER YEAR
GENERAL REFINERY SERVICE
MARKETING PLANTS AND TERMINALS
FILLING LOSS, BBLS.
Note: The throughput is divided by a number (10, 100, 1,000 etc.) to bring it in range of the throughput scale. The filling loss read from the scale must then be multiplied by the same number.

Fig. 2.

Evaluation difficult . . . Thus it is seen that the mechanism of breathing is basically quite simple. Ideally, it should be possible to evaluate the several factors and terms in Equation 1a and to apply coefficients in the proper places in order to calculate breathing losses for a given combination of conditions. However, this problem is enormously complicated.

A review of published data[1,2,3,4] reveals wide discrepancies in the evaluation of individual factors governing evaporation losses. As a result, there appears to be no hope at present of coordinating the many factors to develop Equation 1 of Equation 1a into an acceptable working tool for estimating breathing losses.

Summary of Company Methods

Several companies have developed their own methods for estimating evaporation losses. These methods are the result of piecing together all available bits of data and information into workable formulas, charts, and tables. These are currently being used, and undoubtedly represent the best present approach to the problem of evaluating cone-roof-tank evaporation losses. No one is more aware of the shortcomings

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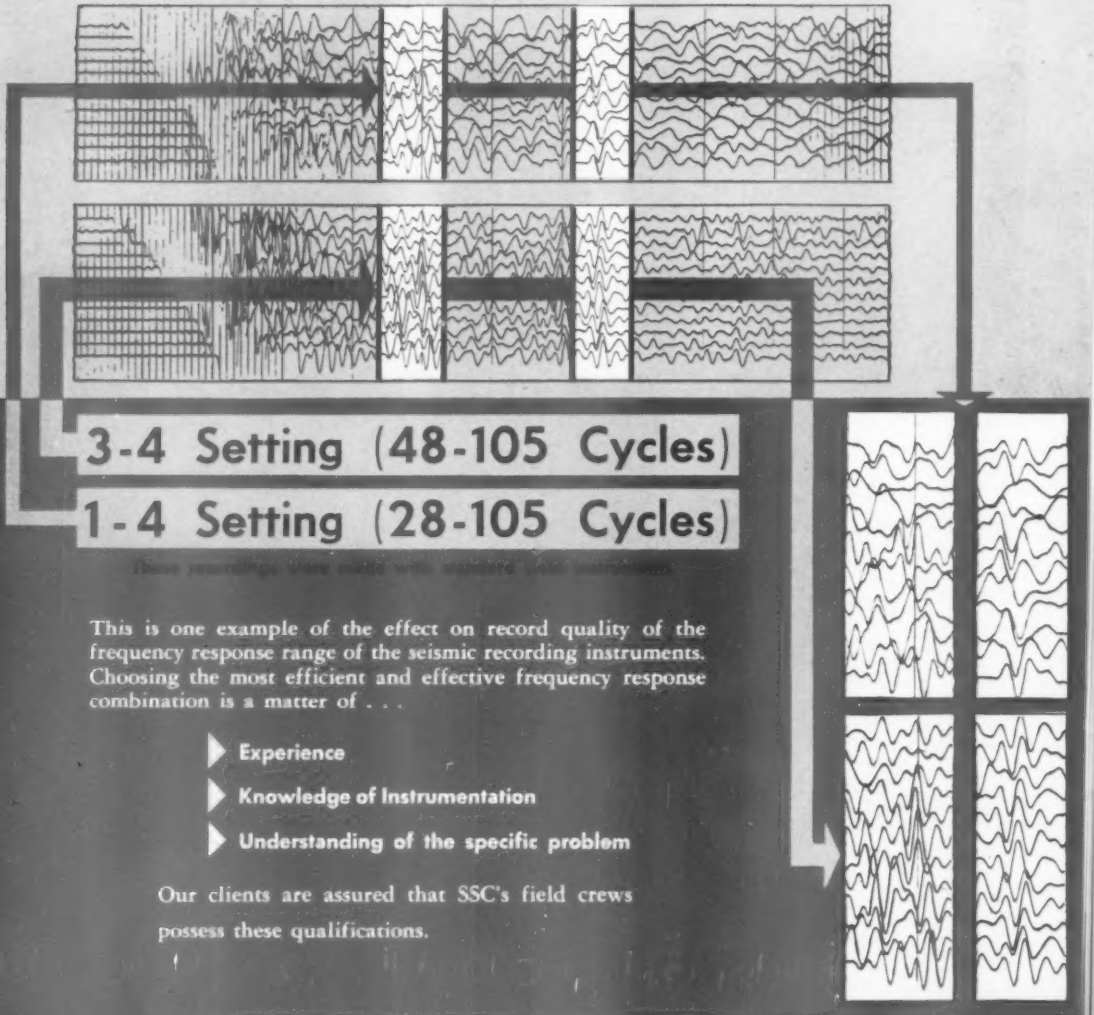

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of the present knowledge of these losses than the men in those companies which have developed these working methods.

Inquiry sent . . . An inquiry, setting up an example for a wide range of tank sizes, was sent to each of eight companies. Estimated breathing loss was requested for the following conditions:

Cone-roof tank with vaportight roof and fittings.

Conservation vent set at ¾ in. of water, pressure and vacuum.

Tank half full.

Stored product, 9.5-lb. R.v.p. gasoline.

Average stock temperature, 60° F.

True vapor pressure at 60° F. = 5 psi.

Annual breathing losses given in the eight replies are summarized in Table 1. The averages are shown in the last column. It will be noted that six of the companies show very good agreement for tank sizes up through 20,000 bbl.

For 55,000 bbl. and over, the spread widens until, at 150,000 bbl., three of the companies are about 27 per cent above the average, and two are about 26 per cent below the average. Considering that, for the 150,000-bbl. tank size, each company presumably extrapolated far above any actual tests, these wide differences are not unexpected.

Equation developed . . . For the 40-ft.-high tanks, the averages from Table 1 fit the following equation very closely:

$$B = D^{1.5}/2.9$$

Where:
B = annual breathing loss, barrels.
D = tank diameter, feet.

Table 2 compares this formula with the averages from Table 1.

Seven of the eight companies figure that losses vary directly with the true vapor pressure. Inasmuch as Table 1 gives estimates based on 5 psi. at the average liquid temperature, we can rewrite the foregoing formula, using the vapor pressure as a variable, thus:

$$B = PD^{1.5}/14.5$$

Where:
P = true vapor pressure at the average liquid temperature, psi.

TABLE 2
Average Breathing Losses for Stated Conditions and for Tanks 40 Ft. High

Diameter (ft.)	Nominal capacity (bbl.)	Breathing loss (bbl. per year) From Table 1	From Equation 2
30	5,000	154	157
42½	10,000	297	291
60	20,000	570	547
100	55,000	1,382	1,373
120	80,000	1,895	1,905
150	125,000	2,753	2,848

TABLE 3—OUTAGE FACTOR F_o FOR BREATHING LOSSES

Outage, feet below top angle	Outage factor (unity for 20 ft.) Company A	Company B	Company C	Company D	Average	From Equation 3
1	0.26	0.28	0.61	0.51	0.42	0.39
5	0.44	0.51	0.69	0.58	0.56	0.55
10	0.64	0.77	0.79	0.69	0.72	0.72
15	0.83	0.91	0.90	0.82	0.86	0.87
20	1.00	1.00	1.00	1.00	1.00	1.00
25	1.17	1.06	1.10	1.20	1.13	1.12
30	1.31	1.12	1.21	1.35	1.25	1.23
35	1.45	1.16	1.31	1.46	1.34	1.33
40	1.59	1.19	1.41	1.52	1.43	1.43
45	....	1.22	....	....	....	1.53
50	....	1.24	....	....	....	1.62

Equation 2 then represents an estimate of the average annual breathing loss from a vaportight cone-roof tank, painted aluminum, with a conservation vent and with 20 ft. of outage to the top of the tank shell. The equation is entirely empirical, but each of its parts has a reasonable meaning.

Losses are assumed to be directly proportional to P. They are also proportional to $D^{1.5}$. If the exponent of D were 2 instead of 1.8, estimated losses would be proportional to the liquid-surface area. The lower value of the exponent makes for a reduction which is in the right direction so as to account for the fact that the ratio of shell area to tank volume decreases as the tank size increases.

Effect of outage . . . Four of the companies gave definite information on the effect of outage. Table 3 gives this comparison, followed by a column showing the average. The average fits the following equation very closely:

$$F_o = \frac{1}{5.7}(H + 5)^{0.57} - 0.1 \qquad (3)$$

Where:
F_o = outage factor (unity for 20 ft.).
H = outage height to top angle, ft.

The values calculated from Equation 3 are given in the last column of Table 3 and extrapolated to 50 ft. of outage. Most tanks have low-pitch cone roofs with a slope of ¾ in. per 12 in. If the volume in the roof is different from this, the outage height H should be adjusted accordingly.

Effect of paints . . . It is generally recognized that heat-reflective paints have an important effect upon temperature changes inside the tank. However, only four companies reported information from which paint factors may be derived.

Table 4 gives this comparison. Based on these averages, chalking white will reduce breathing losses about 25 per cent. Light gray is slightly inferior to aluminum. Black, no paint, or paint in poor condition will increase breathing losses about 25 per cent.

One company reported that new aluminum is considerably better than weathered aluminum, but this is of no practical importance because aluminum paint weathers in a few days to a surface of intermediate heat reflectiveness. Furthermore, in some corrosive and dirt-laden atmospheres, any paint will revert to "black body" heat absorption, thus very quickly increasing the paint factor to about 1.25.

Effect of geographical location . . . The average of predicted breathing losses applies to a set of conditions representing an average climate of the locations where the background tests were made. These climatic conditions vary with geographical location. They include the combined effects of solar intensity, cloudiness, rainfall, wind velocity, atmospheric temperature, and hours of daylight. The relation of breathing loss to all these conditions is far beyond the scope of any tests which have been made.

In the absence of a proven method of handling these secondary variables,

TABLE 4—PAINT FACTOR F_p FOR BREATHING LOSSES

Paint—	Company A	Company B	Company C	Company D*	Use F_p†
Aluminum	1.00	1.00	1.00	1.00	1.00
Chalking white	0.59	0.75	0.91	0.83	0.75
Light gray	....	1.10	1.10	0.92	1.10
Black	1.35	....	1.20	1.25	1.25
No paint	....	....	....	1.25	1.25
Needs repainting	....	....	....	1.25	1.25
New aluminum	0.80	....	....	....	....

*Company "D" factors are for roof only. All other factors are for entire roof and shell painted as stated. †Entire roof and shell painted as stated.

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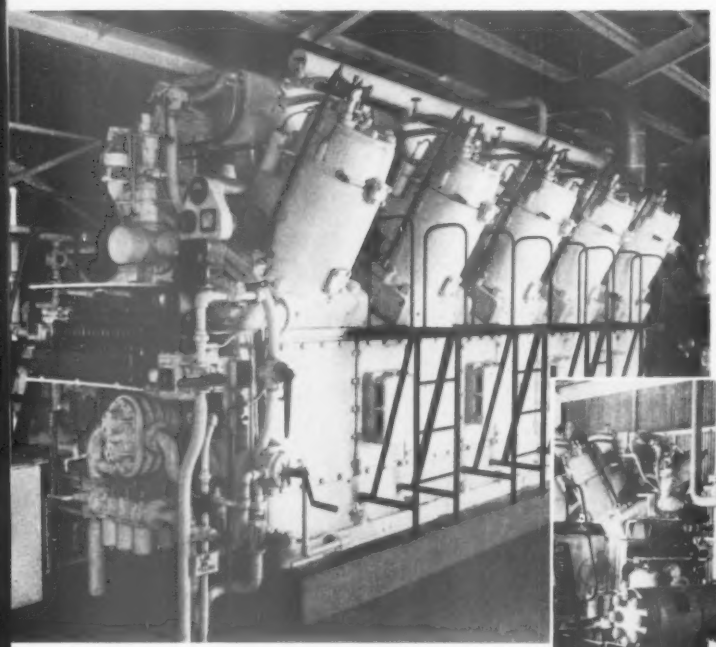
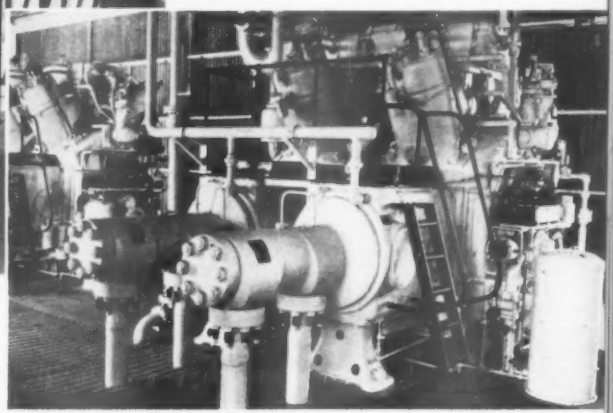


Crankdoor side of one of the GMV-10 process units, showing operating end with automatic control devices.



Close-up of high pressure compressor cylinders on one of the GMV-4 units in recirculator service—first application of its kind.

ANGLE

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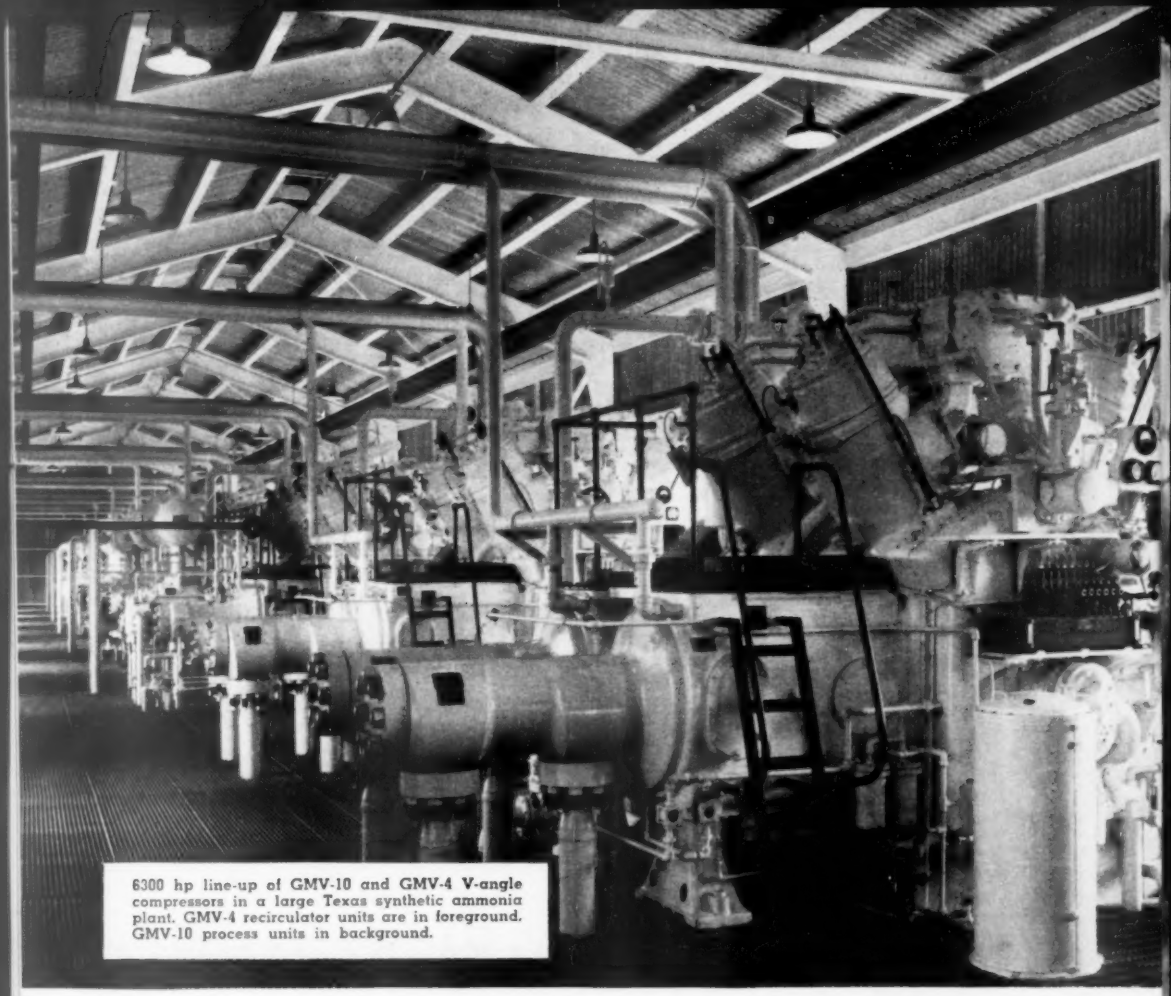

6300 hp line-up of GMV-10 and GMV-4 V-angle compressors in a large Texas synthetic ammonia plant. GMV-4 recirculator units are in foreground. GMV-10 process units in background.

IN this Texas synthetic ammonia plant, these modern, reliable Cooper-Bessemer GMV's help in a big way to keep the process running smoothly. For example, GMV flexibility permits effective, dependable automatic control — set in this case to maintain constant suction pressure.

The compressor line-up consists of seven GMV's. Two are recirculator units — the *first* 2-cycle gas engine compressors to be used for such service. The other five are GMV-10 process units compressing a hydrogen-nitrogen mixture, through 5 stages, from 2 psig to 5300 psig.

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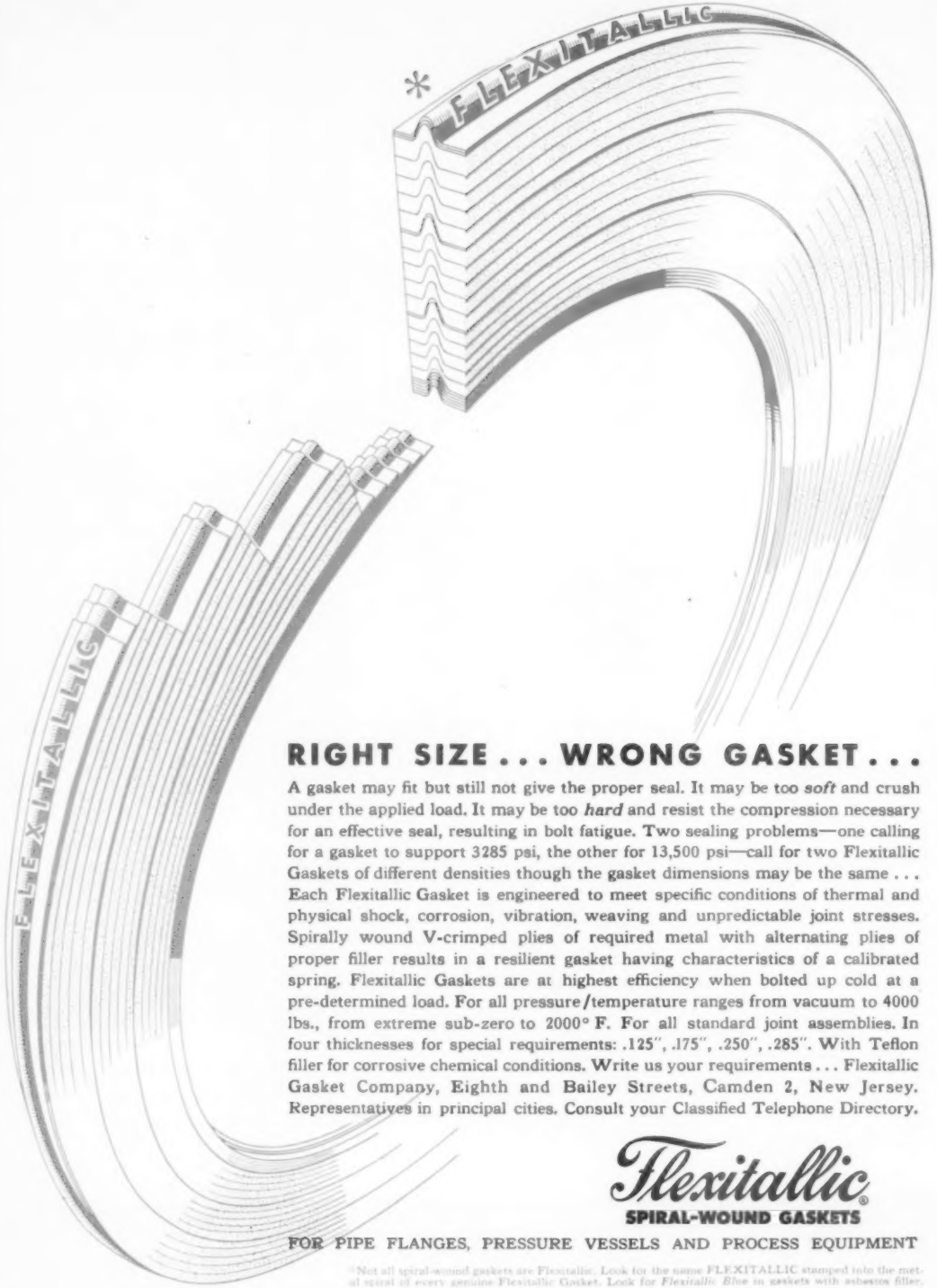

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the committee can only suggest the use of average diurnal temperature change as the simplest approximation of the combined effect of climate at different geographical locations.

An average of the diurnal temperature change (mean daily maximum minus mean daily minimum as reported by the U. S. Weather Bureau) at locations where most of the background tests were made is about 16° F. For a location where the mean daily temperature change is significantly different from 16° F., breathing losses would be adjusted in direct proportion. When greater accuracy is desired, local tests should be made for that particular location.

Recommended equation . . . The recommended equation for breathing loss is then a combination of Equation 2, Equation 3, or F_e, the outage factor, and the paint factor, F_p:

$$B = \frac{PD^{1.5}}{14.5} F_e F_p \qquad (4)$$

F_e is defined by Equation 3.

The values of F_e and F_p are given in Tables 3 and 4.

Effect of Conservation-Vent Settings

Usually, in American practice, conservation vents are not loaded above the minimum practical pallet weight. In most cases this is either ¾ in. of water or ½ oz. per sq. in., depending upon the vent manufacturer. The same setting is used for both the pressure and the vacuum side. The range, therefore, is 1½ in. of water or 1 oz. per sq. in. The value of $G_2 - G_1$ in Equation 1 is, then, 0.054 or 0.062—say 0.060 psi. in the average case.

From Equation 2 and Table 2 it is seen that about 1,373 bbl. of gasoline are lost each year by breathing from a 55,000-bbl. tank standing half full. If the air-vapor mixture vented from the tank is saturated to an average partial pressure of 5 psi., the number of cubic feet of air-vapor mixture per gallon is:

$$Z = (30)(14.7/P) \qquad (5)$$

for gasoline mixtures. Thus:

$$Z = 440/P = 440/5, \text{ or } 88$$

Hence the volume of air-vapor mixture which is vented during the year is 1,373 times 42 times 88, or 5,070,000 cu. ft. per year, or 13,900 cu. ft. per day. The volume of the tank vapor space is 165,000 cu. ft. and hence, the average daily expansion is about 13,900 divided by 165,000, or 8.4 per cent. Then the quantity in brackets in Equation 1a must be equal to 8.4:

$$\left[\left(\frac{T_2 - T_1}{T_1 + 460}\right) + \left(\frac{P_2 - P_1}{A + G_2 - P_2}\right) - \left(\frac{G_2 - G_1}{A + G_2 - P_2}\right)\right] = 8.4$$

Decrease in loss . . . In the denominator of the third term A is 14.7; G_2 is negligible; and P_2 is effectively about 5. Then $A + G_2 - P_2$ is equal to 9.7. If the pressure-vent setting is increased 1 oz. per sq. in., the third term would increase about 1/(16) (9.7), or 0.65 percentage points. This would decrease the total expansion by the same amount which, expressed as a percentage of the original total expansion, is 0.65/8.4, or 7.7 per cent. Hence it would appear that each ounce increase in vent setting should reduce breathing losses about 7.7 per cent.

This figure is supported by Sarjeant,[5] who states that a pressure setting of 8 in. and a vacuum setting of 2½ in. of water results in a saving of about 50 per cent of the breathing loss. The 10½-in. range is equivalent to 6.1 oz. per sq. in., and the claimed saving is about 8.2 per cent per ounce of increased setting. This possible saving per ounce decreases as the pressure range increases because the point is reached where, on some days, all of the pressure range is not utilized. About 2½ psi. or 40 oz. per sq. in. is required to prevent practically all breathing loss.

It should not be concluded that elevated vent settings should be used as a conservation measure. Large cone-roof tanks are inherently weak against pressure and vacuum. The small available reduction of evaporation loss does not justify the added risk of structural damage to the tank.

Filling Losses

The theoretical approach which explains the mechanism of filling losses is a little more straightforward than that of breathing losses. Fewer variables have a direct effect on their magnitude. Basically, filling losses are caused by the displacement of air-vapor mixture from the tank by the introduction of liquid into the tank. If the partial pressure of the vapor in the air-vapor mixture is P, the number of cubic feet per gallon is obtained from Equation 5.

The displacement loss is, therefore, 1 gal. for every 440/P cu. ft. pumped into the tank, or 1 gal. for every (440) (7.48)/P gal. pumped in. If V gallons are pumped into the tank, the loss is, therefore:

$$F = \frac{PV}{(440)(7.48)} = \frac{PV}{3{,}300}$$

$$F = \frac{3\,PV}{10{,}000} \qquad (6)$$

Where:
F = filling loss, bbl.
P = vapor pressure, psi.
V = volume of liquid pumped in, bbl.

Equation 6 is the basic formula for filling losses. The value of P is usually taken as the vapor pressure at the average tank-liquid temperature. This accounts for some lack of complete saturation because the maximum temperature and the average temperature at the liquid surface are somewhat higher.

Higher basic loss proposed . . . Happel and Heath[6] have proposed that a higher basic loss be used. In normal bulk-plant operation a number of small withdrawals are made for each fill. Data are given to show that the rate of saturation is low enough so that a volume of air equal to the volume of withdrawal is drawn in and then saturated. Under this condition they show that the filling loss is:

$$F = \frac{PV}{225\,(14.7 - P)}$$

TABLE 5—ESTIMATED FILLING LOSSES FROM CONE-ROOF TANKS—COMPARISON OF SEVERAL COMPANY METHODS

True vapor pressure at mean temperature (psi.)	Estimated filling loss (per cent of throughput)							
	Company A	Company B	Company C*	Company D	Company E†	Company F†	Company G	Company H
2	0.06	0.04	0.049	0.090	0.06	0.070	0.06	0.070
3	0.09	0.065	0.073	0.134	0.09	0.113	0.09	0.114
4	0.12	0.09	0.097	0.177	0.12	0.165	0.12	0.166
5	0.15	0.11	0.122	0.220	0.15	0.227	0.15	0.229
6	0.18	0.13	0.146	0.264	0.18	0.304	0.18	0.307
7	0.21	0.15	0.170	0.307	0.21	0.400	0.21	0.404
8	0.24	0.18	0.194	0.346	0.24	0.526	0.24	0.531
9	0.27	0.20	0.219	0.386	0.27	0.688	0.27	0.702
10	0.30	0.22	0.243	0.426	0.30	0.849	0.30	0.946

*Losses shown are for 5,000-bbl. tanks. See Table 6 for tank-size factor. †Losses shown are for low throughput. See Table 7 for throughput factor.

TABLE 6—FACTOR FOR TANK SIZE

Capacity (bbl.)	Company B	Company C
5,000	1.00	1.00
20,000	0.96	0.92
40,000	0.92	0.81
60,000	0.87	0.71
80,000	0.82	0.60
100,000	0.77	0.49
120,000	0.73	0.39

This loss is $\frac{14.7}{14.7 - P}$ times as great as the basic loss from Equation 6. This type of loss occurs in two stages. One takes place after the completion of a withdrawal, when the air is saturated shortly after having been drawn in. The second occurs when the same amount of liquid is replaced in the tank, causing a displacement loss equal to F from Equation 9. One large group of companies uses this method, thereby estimating filling losses in cone-roof tanks considerably greater than the loss caused by the straight displacement of air-vapor mixture.

Tables 5, 6, and 7 summarize and compare methods for computing filling losses.

Company "E" appears to have the most logical and complete method for the throughput factor. These throughput factors are supported by unpublished tests which are more extensive and persuasive than those of any other company. It is recommended, therefore, that Equation 6 be modified by a factor, K_T, taken from the method of Company "E" and given in Table 8. The recommended formula for filling loss then becomes:

$$F = \frac{3\,PV}{10{,}000} K_T \qquad (7)$$

and K_T is taken from Table 8.

Vent settings in the order of less than 1 oz. per sq. in., such as are ordinarily used for tanks of this class, have practically no effect on filling losses.

Boiling Losses

For the Gulf Coast, Atlantic seaboard, and the northern Middle West, the maximum liquid-surface temperature is about 100° F. For the Mid-Continent area and the arid Southwest, temperatures as high as 115° F. are encountered. On the West Coast, at locations directly tempered by the Pacific Ocean, the maximum liquid-surface temperature may be as low as 80° F.[3]

TABLE 8—THROUGHPUT FACTOR K_T FOR FILLING LOSSES

Tank turnovers per year	Value of K_T: General refinery service	Value of K_T: Marketing plants and terminals
0-10	1.00	1.00
12	0.91	1.00
15	0.75	1.00
20	0.59	1.00
25	0.50	1.00
30	0.47	1.00
40	0.44	1.00
40-60		0.80
60-100		0.50

For this range of temperature, the maximum Reid vapor pressures of stocks which can be stored without general boiling (but at the expense of very high loss rates) in tanks which operate at essentially atmospheric pressure are given in Table 9. These Reid vapor pressures are obtained directly from the vapor-pressure chart. They must be reduced for locations at high altitude to account for lower barometric pressure.

Some reduction of the maximum temperature can be achieved by tank insulation, use of white paint, or by allowing part of the stock to boil off to a recovery system. However, the preferred conservation method appears to be the use of tanks capable of withstanding the required internal pressure.

Tank Condition

Open vents result in enormously higher losses from tanks which store volatile liquids. Any leak in a tank roof or accessory is equivalent in some degree to an open vent. Gusty or turbulent winds across an open vent cause rapid pressure variations at the vent. In brisk winds, pressure variations in the order of ¼ in. of water have been observed. This causes a rapid breathing in the form of short puffs, with resulting high evaporation loss.

When there are two or more openings into the tank vapor space, losses are greatly accelerated. Wind and air-pressure differences cause a constant flow of air into the vapor space through one or more openings, while other openings permit a constant outflow of air-vapor mixture.

TABLE 9
Maximum Reid Vapor Pressure of Stocks Which Will Not Boil When Stored at Atmospheric Pressure

Maximum liquid-surface temp. (° F.)	Maximum Reid vapor pressure (lb.)
80	18
90	15.5
100	13.5
110	11.5
120	10

Vapors outside the tank always furnish a potential source of ignition. Windage through tank openings creates a reduced degree of saturation in the vapor space, so that it is more likely to be within the flammable range and susceptible to ignition from an external source.

Only one of the companies evaluates losses caused by open vents and leaks. This company treats leaks as an increase in breathing losses by including a tank-condition factor in the formula for estimating breathing losses. The condition factor is based upon the degree of leakage of the tank roof and fittings.

It is determined as the sum of all of the individual items which contribute to leakage, listed in Table 10, which are applicable to the tank in question. Thus the condition factor for a tank of gastight construction, but which has an open vent, nongastight gage hatch, and nongastight float gage, would be 1.0 + 0.5 + 0.2 + 0.1 = 1.8. Table

TABLE 10—GASTIGHT-CONDITION FACTOR

Base factor for:	
Gastight tank and fittings	1.0
Add for:	
Leaky float gage	0.1
Leaky gage hatch	0.2
Leaky manhole cover	0.3
Open vent	0.5
Open gage hatch	0.5
Leaby roof construction	0.5
Bad physical condition of roof	1.0 to 8.0

This table is intended to be used as a rough rule for justifying the cost of maintaining or repairing leaky roofs and fittings. When the condition factor exceeds about 2.0, this increased loss should not be added to the full amount of the filling loss because high windage results in an abnormally low vapor concentration inside the tank.

TABLE 7—FACTOR FOR THROUGHPUT

Tank turnovers per year	Company E (*)	Company E (†)	Company F P = 2	Company F P = 5	Company F P = 8
0-10	1.00	1.00	1.00	1.00	1.00
12	0.91	1.00	1.00	1.00	1.00
15	0.75	1.00	0.86	0.66	0.46
20	0.59	1.00	0.86	0.66	0.46
25	0.50	1.00	0.86	0.66	0.46
30	0.47	1.00	0.86	0.66	0.46
40	0.44	1.00	0.86	0.66	0.46
40-60		0.80	0.43	0.33	0.23
60-100		0.50	0.43	0.33	0.23

*General refinery service. †Marketing plants and terminals.

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10 is intended as a rough tool to be used for justifying the cost of maintenance and repair to keep a cone-roof tank in gastight condition.

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3. Losses From Conservation-Roof Tanks

By Group C Subcommittee, A.P.I. Division of Marketing

THE conservation-type tank is finding increasingly greater application in the storage of all volatile petroleum products. The primary reason for this lies in the reduction of breathing and filling losses normally experienced in cone or fixed-roof tanks.

The floating-roof tank is used for all volatile products which will not boil at storage temperatures, and is the most important conservation tank used for the storage of crude oil. The variable vapor-space tank is used almost entirely for motor and aviation-gasoline storage. The low-pressure tank is usually used for products with vapor pressures too high to be stored in the other types of conservation-type tanks.

Floating-Roof, Conservation-Type Tank

All standing storage losses have been reduced to the same common denominator; i.e., standing storage losses are expressed as barrels per foot diameter per year per pound of true vapor pressure. In this connection, it should be carefully noted that wherever the term "true vapor pressure" appears in this report, it refers to the pressure determined by taking the average Reid vapor pressure and converting it to true vapor pressure by means of the average temperature of the liquid.

Storage-loss data, riveted tanks . . . The losses reported by investigators on all riveted tanks vary from a low of 0.37 to a high of 1.42 bbl. per foot diameter per year per pound of true vapor pressure. In most cases the data indicate that the loss rate is constant, regardless of the size of the tank considered—although one company reports an increase in this figure as the tank diameter is increased. The data obtained by this company, however, do indicate that the rate of loss per area unit is constant. The committee believes that the loss rate is not directly constant either with relation to diameter or area. However, the data do indicate that the approach to a constant value is more nearly met by using the tank diameter rather than the area.

A weighted average of the test data available to the committee indicates that the standing storage loss should be:

Floating-roof tank, riveted shell, double-seal: 0.56 bbl. per foot diameter per year per pound of true vapor pressure.

It is not necessary to conduct further tests on this type of tank, because this figure should be attainable on all double-seal tanks in good condition where there is a good fit of shoe and seal to shell.

Butt-welded tanks . . . On a butt-welded tank it is possible to obtain a much closer fit of roof to shell than is the case with a riveted tank because of the absence of the rivet protrusions and lap joints.

The available loss data indicate that standing storage losses on most types of welded tanks, both single and double-seal, do not vary greatly. The data indicate a loss expectancy on welded tanks ranging from 0.30 to 0.54 bbl. per foot diameter per year per pound of true vapor pressure. A careful analysis of all data indicates that the average standing storage-loss expectancy is as follows:

Floating-roof tank, welded shell, single or double-seal: 0.49 bbl. per foot diameter per year per pound of true vapor pressure.

In the case of the welded tanks, one of the contributors indicated an increase in loss with an increase in the size of the tank. It is believed that this increase is of relatively small magnitude and, accordingly, may be disregarded for most practical purposes.

Tank comparisons . . . To the extent that the data presented in this report may be considered conclusive, it is apparent that, if a floating roof is used on a riveted tank, it is good economy to use a double seal. When repairs are made, it is advisable, particularly on gasoline stocks, to install the secondary seal even though it was not furnished originally.

As regards the comparison between welded shell tanks and riveted shell tanks, the welded tank naturally shows a somewhat decreased standing loss for the reason that a better fit can be obtained between shoe and seal, thereby decreasing the liquid surface exposed to the effect of evaporation and varying wind velocities.

Filling Losses

The industry has customarily considered that the filling losses on a floating-roof tank may be considered negligible for all practical purposes. Data obtained by one oil company indicate that an average filling-loss figure would be approximately of the order of 0.02 per cent of throughput.

The filling loss may be considered as the sum of two separate losses:

1. Loss due to wetting shell.
2. Loss due to wicking.

The loss due to wetting the shell is proportional to shell area and throughput, and tests which involve a rusty surface have indicated that these losses are of the order of 0.005 per cent of throughput.

Losses due to wicking are induced by capillary action on the surfaces between the shell and the shoe, and they represent a loss of the total constituents of the gasoline rather than any selective fraction thereof. It would seem that the magnitude of the wicking loss is determined by the degree of rusting of the shell and by the closeness of fit of the shoe to the shell.

There are almost no reliable data on filling losses, and some of the data which are available were obtained on floating-roof tanks some 12 years ago. However, filling losses would be affected less by the type of floating roof employed than by the degree of rusting on the shell.

Inasmuch as authorities agree that there is some filling loss which is usually termed negligible, and as considerable data on losses generally are in excess

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Members of Group "C" subcommittee include E. L. Hoffman (chairman), Socony-Vacuum Oil Co., Inc., New York; N. Friz, Esso Standard Oil Co., New York; R. N. Giles, Standard Oil Co. (Indiana), Chicago; H. L. O'Brien, Graver Tank & Manufacturing Co., East Chicago, Ind.; F. L. Plummer, Hammond Iron Works, Warren, Pa.; H. E. Simonson, Phillips Petroleum Co., Bartlesville, Okla.; A. B. Stevens, General Petroleum Corp., Los Angeles; J. H. Wiggins, General American Transportation Co., Chicago; and I. L. Wissmiller, Chicago Bridge & Iron Co., Chicago.

of what may be deduced from the standing storage loss of 0.005 per cent shown previously, it has been agreed that a suitable compromise would be the use of an average figure of 0.01 per cent loss based on total throughput:

Filling losses, floating-roof tanks, all types = 0.01 per cent of throughput.

Economics of Floating-Roof Tanks

A conservation-type tank is justified over a cone-roof tank or over another type of conservation tank only when the economies secured thereby result in a reasonable payout over the incremental cost incurred by its purchase.

Calculations have not been converted to "reasonable payouts" because such determinations are dependent on costs of conservation equipment, tax structure, and company policy—among other factors. Rather, we have chosen several typical, but arbitrary, examples of the value of losses from conservation equipment for comparison with the value of losses from the unprotected equipment.

In the examples chosen there are three sizes of tanks with two throughputs for each tank size. The throughputs are given both in barrels and in turnovers, as indicated in Table 1.

In Table 1, 6 and 20 turnovers annually were chosen for the reason that, for turnovers less than 6, the floating roof would not normally be used, whereas for turnovers greater than 20, the floating roof would normally always be used. Intermediate conditions, of course, would require interpolation.

The average annual Reid vapor pressure has been assumed at 10 lb. which, at an average temperature of 60° F., will correspond to a true vapor pressure of 5.2 lb. The value of the gasoline has been arbitrarily assumed at 10.0 cents per gallon, or $4.20 per barrel.

If it is desired to compute losses based on different sizes of tanks and on these data for throughputs, Reid vapor pressure, temperature, and laid-down cost, it can be done as in the examples given in Table 1.

Conclusion

As the floating-roof tank has a very low filling loss, it is particularly advantageous when products with a high throughput rate are stored, viz., when the number of annual turnovers is great. The economics must be determined as indicated in the foregoing discussion. In the case of crude oils and stocks of lower volatility or value, a larger number of turnovers would be necessary to insure arriving at a reasonable payout.

By means of the foregoing description, formulas, and accompanying numerical results, it is felt that the economic feasibility of floating-roof tanks can be determined with reasonable accuracy. Independent of payout periods derived from the reduction of evaporation losses, there are several characteristics of floating-roof tanks which may indicate their selection over other types of conservation equipment. In the storage of sour crude, for instance, floating roofs enjoy a distinct advantage in that the vapor space—present in all other types of storage—is virtually eliminated.

Another consideration of petroleum-product storage, in which the floating roof stands to particular advantage, would be that of attendant fire hazard.

On the other hand, the floating roof, to be successfully operated in severe northern climates, will probably require diligent maintenance. Snow and ice which collect on the roof must be removed if there is danger of overload. The more severe the winter conditions, the more care is required in operation—even to the extent that floating roofs may be eliminated from consideration.

Floating-roof tanks are more difficult to gage accurately, particularly when the roof is not floating but is resting on its supports. However, this is not necessarily a serious limitation for, in normal operation, the roof should be floating. It is also important, in the interest of accuracy, to account for overloads such as snow, ice, or water.

The Low-Pressure-Type Tank

Breathing losses . . . In the previous general discussion it has been pointed out that, from the theoretical approach at least, it is normally not difficult to estimate a design pressure which will eliminate breathing losses from the product stored. For most standard gasolines, breathing losses may be almost entirely eliminated by a pressure setting of 2½ psig.

A careful survey of pressure tanks in general, however, has indicated that some vapor-escape losses may occur, although in some cases the rate of loss experienced was quite low. Because, in general, the tanks tested and their venting equipment had been well maintained, it may be concluded that there are two possible conditions under which breathing losses may be experienced from pressure tanks, (1) there may be leaks in the tank or fittings, and (2) there may be automatic venting of the tank due to temperature rise.

Although for all practical purposes breathing losses are slight, some do occur, and may be listed empirically as 5 per cent of the breathing losses experienced in cone or fixed-roof tanks. Even this conclusion will only be valid, however, if every precaution is taken to assure that tank fittings and venting equipment are in good condition and that the tank itself is substantially vaportight:

Breathing loss, low-pressure tanks, all types = 5 per cent of cone-roof-tank breathing losses.

Filling losses . . . In a discussion of filling losses, it is important to note that filling losses will occur only if the vapor pressure of the product is sufficiently low so that air is drawn into

TABLE 1

	Size of tank—Bbl.	Size of tank—Ft.	Throughput (bbl.)	Turnovers (times)
(a) Case I	20,000	60 x 40	120,000	6
			400,000	20
(b) Case II	55,000	100 x 40	330,000	6
			1,100,000	20
(c) Case III	80,000	120 x 40	480,000	6
			1,600,000	20

Losses on Floating-Roof Tanks—Motor-Gasoline Pontoon-Roof Welded Tanks, Single or Double Seal

	Case I		Case II		Case III	
Tank capacity, bbl.	20,000		55,000		80,000	
Annual throughputs (turnovers)	6	20	6	20	6	20
Annual loss, bbl.:						
1. Standing	153	153	255	255	306	306
2. Filling	12	40	33	110	48	160
Total	165	193	288	365	354	466
Value of loss	$693	$811	$1,210	$1,533	$1,487	$1,957
Increase in maintenance over cone-roof	376	376	628	628	755	755
Total annual equivalent loss	$1,069	$1,187	$1,838	$2,161	$2,242	$2,712

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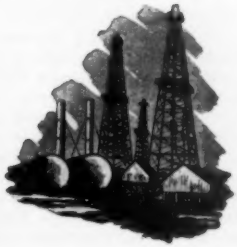

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the vapor space, or if filling is done at such a rate that equilibrium conditions are not maintained continuously between the vapor and the body of the liquid, thus resulting in a possible build-up of pressure.

Inasmuch as we are considering only stabilized refined gasolines (or natural gasolines used for blending purposes) in our discussion, it is inevitable that air is drawn in, and filling losses do occur and must be considered.

The amount of the loss may be estimated as follows: Assume a vessel to be almost empty or partly filled, with the vacuum vent on the verge of opening and a mixture of air and vapor in the vapor space. As the vessel is filled, the air is compressed, thus increasing its partial pressure; and vapor condenses so that its partial pressure remains practically constant. Finally, the total pressure becomes equal to the gage pressure at which the pressure-relief vent opens. From this time on, as filling continues, the saturated air-vapor mixture in the vapor space will be displaced through the pressure-relief vent until filling ceases and, therefore, this vapor will be lost.

When a pressure tank is filled, venting will not start immediately, but will be delayed in accordance with the operation of several variables as follows:

1. The pressure in the tank at the start of filling in relation to the maximum operating pressure.
2. The volume of the vapor space above the liquid.
3. The effective vapor pressure of the liquid in the tank and the filling liquid.
4. Atmospheric conditions during time of filling with reference to temperature; i.e., is the temperature rising or falling?
5. The amount of air in the tank.
6. The rate of filling.

There are other variables, but these are the most important. Based on actual test data, it may be stated as a general conclusion that, if a tank has up to 10 turnovers per year, particularly if the fills are of relatively small amount, it should normally be possible to delay the start of venting until 25 per cent of the total liquid fill has been added to the tank.

Once venting has started, the loss during subsequent filling may be plotted with sufficient accuracy by a simple equation. To determine the loss, it is necessary to know the total volume of vented air-vapor mixture which may be found from the gage readings and vapor-space temperature, as well as the effective vapor pressure, which may be determined by analysis of samples of vented vapor. These values are then used in the equation:

$$\text{Gallons of gasoline lost during venting} = \left(\frac{V}{(7.5)(30)}\right)\left(\frac{p}{14.7}\right)\left(\frac{520}{T}\right)$$

where:

V = volume of fill after venting starts (determined by gage readings)
p = effective vapor pressure of gasoline, psia.
T = temperature of vapor, °F., absolute

It is apparent that, for all practical purposes insofar as motor gasolines are concerned, when venting has once started the rate of loss is similar to that in a cone-roof or variable vapor-space tank.

Filling losses, low-pressure tanks, all types—for motor gasoline—0 to 10 turnovers annually = 75 per cent of cone-roof tank-filling losses.

For motor gasolines the rate of loss is still about the same for more than 10 turnovers, i.e., 75 per cent of cone-roof filling losses; but, for more than 10 turnovers, economics would usually dictate another one of the various types of conservation tanks.

Economics . . . A pressure-type tank is justified over a cone-roof tank or another type of conservation tank only when the economies secured thereby result in a reasonable payout over the incremental cost incurred by its purchase.

In general, the major disadvantage of the pressure tank is the high initial cost and, in this respect—regardless of the actual design used—it usually compares unfavorably with most other types of conservation tanks.

If there is apt to be any shell corrosion, this difficulty may be accentuated in view of the fact that the thinness of metal in the design of the spheroid will not permit of much loss of metal due to corrosion and, in cases of this kind, the allowable liquid level and possibly the working pressure may have to be reduced.

A second serious difficulty is that, obviously, because of the pressure involved, the pressure tank cannot be interconnected with a cone-roof tank.

The vertical-shell pressure tanks, both with noded and flat bottoms, appear to overcome many of the spheroid disadvantages, particularly that of cost, but they are rather limited in size. Although cheaper (per barrel of capacity) than the standard spheroid, they are usually more costly than the flexible-diaphragm type of tank.

Examples . . . In the examples chosen there are three sizes of tanks with two throughputs for each size. The size of tank, throughput in barrels, and turnovers are given in Table 2.

In the examples given it was assumed that motor gasoline was the product stored at a true vapor pressure of 5.2 lb. The average annual Reid vapor pressure has been assumed at 10 lb. which, at an average temperature of 60° F., will correspond to a true vapor pressure of 5.2 lb. The value of the gasoline has been arbitrarily assumed at 10.0 cents per gallon, or $4.20 per barrel.

The data on breathing losses represent 5 per cent of the value obtained

TABLE 2

	Size of tank		Throughput	Turnovers
	Bbl.	Ft.	(bbl.)	(times)
(a) Case I	20,000	60 x 40	60,000	3
			200,000	10
(b) Case II	55,000	100 x 40	165,000	3
			550,000	10
(c) Case III	80,000	120 x 40	240,000	3
			800,000	10

Losses on Low-Pressure Tanks

	Case I		Case II		Case III	
	*3 Turnovers	10 Turnovers	*3 Turnovers	10 Turnovers	*3 Turnovers	10 Turnovers
Tank capacity, bbl.	20,000	20,000	55,000	55,000	80,000	80,000
Number of days in service	365	365	365	365	365	365
Throughput, bbl. per year	60,000	200,000	165,000	550,000	240,000	800,000
Annual loss, bbl:						
1. Breathing	29	29	71	71	99	99
2. Filling	70	234	193	644	281	936
Total	99	263	264	715	380	1,035
Value of loss	$416	$1,105	$1,109	$3,003	$1,596	$4,347

*Three turnovers were chosen arbitrarily, but might represent a typical condition of use. Obviously, for 0 turnover, there could only be a slight breathing loss.

for cone-roof tank-breathing losses in report on "losses for cone-roof tanks." (Tanks are one-half full, and painted aluminum.)

The filling losses shown in the examples would be reduced as the vapor pressure of the gasoline product stored increased—to the point that, where the true vapor pressure of the product was sufficiently high under all conditions, the filling losses would approach zero. In fact, for stocks of sufficiently high vapor pressure, the low-pressure tank is the only type which should be considered.

In limiting our operating pressure to 2½ to 15 psig., however, we are automatically restricted to natural gasolines and to motor gasolines which may or may not contain some admixture of natural gasoline.

Results . . . Two factors are found to affect greatly calculations of vapor losses from low-pressure tanks:

1. The effective vapor pressure of gasoline in a storage tank is apt to be a very different quantity from the vapor pressure corresponding to the temperature of the liquid. The proportion of gasoline vapor to air in one spheroid tested was found to be consistently higher than predicted by the "law of partial pressure," using a gasoline vapor pressure corresponding to the temperature of the body of the liquid.

This, of course, might represent a state of supersaturation, but extreme doubt is felt that any such condition could exist for any length of time. The method of analysis of vapor samples offers a means of arriving at effective vapor pressures and surface temperatures—much more practical than any means of direct measurement.

2. Care must be taken that proper correction is made when the value of 30 cu. ft. of vapor per gallon of gasoline is used. It must be remembered that a gallon of gasoline occupies 30 cu. ft. when at a temperature of 60° F. and under a pressure of 14.7 psi. When the vapor being considered is at another temperature or pressure than this, correction must be applied. If the pressure of the vapor is P and its absolute temperature is T, then the cubic feet per gallon of gasoline is:

$$(30)\quad \left(\frac{14.7}{P}\right)\left(\frac{T}{520}\right)$$

There are three possible conditions under which losses may occur from low-pressure tanks. Following are some suggestions as to how these results may be applied in the future, under each of the three conditions:

1. There may be leaks in the tank or fittings.

2. There may be automatic venting of the tank due to temperature rise.

3. Vapors are lost during filling of tanks. The amount of the vapors lost may be determined theoretically and with a reasonable degree of accuracy. The most economical method of operation would include the following:

(a) Deliveries to the tank should preferably be made in the afternoon or evening, rather than in the forenoon, so that periods of falling temperature may be obtained.

(b) At the time of filling, the tank inventory should be low, consistent with good operating practice.

(c) Displacement losses are minimized by more frequent receipts of lesser volume.

These conclusions are applicable only when they do not conflict with good operating practice. Thus, in winter time, it may be necessary to carry higher inventories to forestall possible failure of delivery.

The Variable Vapor-Space Tank

Standing storage losses . . . The vapor-storage capacity of the variable vapor-space tank system, whether an integrated or separate unit, is so designed that, under all normal conditions of operation, breathing losses are substantially eliminated. The size would naturally depend on the amount of vapor space in the conservation tank and any interconnected cone-roof tankage, which may be subject to expansion; and, for most practical purposes in minimizing losses, the average liquid innage in the tank system is considered in the range of empty to half full (vapor capacity would range from 100 to 50 per cent of total capacity).

A practical compromise, used by some companies and suggested by some manufacturers, is that the total tank innage be assumed not to go below one-third full, in which case the fixed vapor space would be two-thirds of the total tank capacity. This does not mean that, if the total average liquid innage is less than one-third full, there will be breathing losses, inasmuch as the other factor in design, viz., the increase in temperature of the vapor space, is predicated on a higher than average daily temperature fluctuation.

The vapor capacity of the total variable vapor-space tank system will normally approximate 8 per cent of the total liquid capacity, with a range of from 6 to 10 per cent.

Standing storage-loss data . . . If the system has been properly designed, breathing losses as experienced by the cone-roof tank are theoretically eliminated and, in practice, substantially eliminated. Even with proper design, however, breathing losses are not completely eliminated for the following reasons:

1. In all variable vapor-space systems, especially those operating at 2 to 3 oz. per sq. in. pressure, the tanks and accessories must be absolutely vapor-tight to prevent vapor leaks. Some vapor losses may be incurred in gaging and sampling operations.

2. On liquid-seal lifter tanks, there is a solubility effect of the vapor in the seal liquid and consequently evaporation of the absorbed liquid. Some condensate also may find its way into the seal liquid and evaporate.

3. On flexible-diaphragm type of tanks and, to a lesser extent on dry-seal lifters and gasholders, there is the effect of permeability of vapor through the flexible-diaphragm membrane.

There is the usual scarcity of field data on variable vapor-space tanks, but some Chenicek and Whitman data taken on liquid-seal lifter tanks some 12 years ago indicate that breathing losses are, in fact, experienced. Recent gage data on flexible-diaphragm tanks also indicate breathing losses; and, although in both cases at least a portion of this loss may be ascribed to vapor leaks sustained in gaging and sampling operations and in auxiliary equipment, it is difficult to indicate the relative value of controllable and noncontrollable loss.

The following breathing losses, then, may be predicted based on our present knowledge:

Breathing losses, variable vapor-space tank, integrated and separate = 10 per cent of equivalent cone-roof tankage breathing losses (actual loss varies from 5.0 to 15.0 per cent).

The figure of 10.0 per cent refers to equivalent liquid capacity only.

Filling losses . . . In this regard, all variable vapor-space tanks or systems will undergo the same losses; i.e., there will be no filling loss until the full vapor capacity of the tank or system has been reached and, after this time, additional filling will result in losses substantially the same as those experienced by a cone-roof tank.

The point at which venting will start is dependent upon many factors, chief among which are the total vapor capacity of the system, the amount of available excess vapor capacity at the time filling is started, the total amount of filling, and whether there are concurrent withdrawals. In connection with throughputs, losses are greater when larger individual batches are received.

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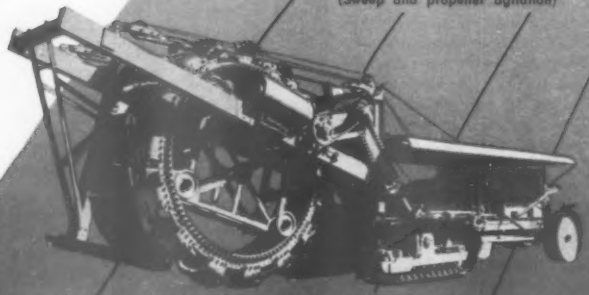

C-R-C "Big Injun" Ditching Machines for trench digging from 32" to 52" wide and 8' 6" deep.

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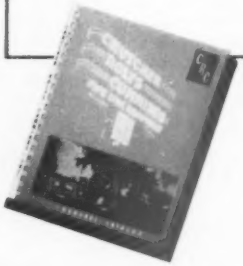

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Steamer and barge deliveries usually represent large batches and high filling losses; pipe-line deliveries represent intermediate batches and losses; whereas truck-transport and tank-car deliveries usually represent relatively small batches and low filling losses. Other factors include the rate of change of temperature in the vapor space, whether rising or falling, as well as the true vapor pressure of the product being handled.

Accordingly, it is necessary to know all the factors relating to a particular installation before an estimate of the filling loss to be expected can be made with any degree of accuracy. Under conditions usually experienced, this will average from as low as 25 per cent to as high as 90 per cent of equivalent cone-roof tank-filling losses.

In estimating savings in filling losses in variable vapor-space systems where normal design bases have been used, it is customary to consider that the system, at the time filling starts, has one-half of the total excess vapor capacity available for reduction of filling losses. If the average amount of fill and other pertinent factors are known, an approximation can be made of the savings to be realized. As with the pressure tank, although it is impossible to attempt to indicate exactly when venting starts, we have selected a reasonable average percentage of cone-roof losses, and these data are as follows:

Filling losses, variable vapor-space tanks, all types, for 0 to 10 turnovers annually = 75 per cent of cone-roof tank-filling losses.

Economics . . . A conservation-type tank is justified over a cone-roof tank, or over another type of conservation tank, only when the economies secured thereby result in a reasonable payout over the incremental cost incurred by its purchase.

In comparison with a cone-roof tank, it is obvious that the greater the throughput in the tank, up to a certain limiting value, the greater the advantage of the variable vapor-space tank over the cone-roof tank.

In the examples chosen there are three sizes of tanks with two throughputs for each tank size. The throughputs are given both in barrels and in turnovers, as indicated in Table 3.

The data on breathing losses and filling losses shown in Table 3 were taken using percentages of the cone-roof loss obtained from the report on "Losses From Cone-Roof Tanks" (tanks one-half full, aluminum paint). In the foregoing examples three turnovers annually were chosen arbitrarily, but might represent a typical condition of use. For more than 10 turnovers annually, the floating-roof tank would probably be used. Intermediate conditions, of course, would require interpolation.

The average annual Reid vapor pressure has been assumed at 10 lb. which, at an average liquid temperature of 60° F., will yield a true vapor pressure of 5.2 lb. The value of gasoline has been assumed at 10.0 cents per gallon, or $4.20 per barrel. If it is desired to compute losses based on different size tanks and for different throughputs, Reid vapor pressure, temperature, and laid-down cost, this can be done as in the foregoing examples.

TABLE 3

	Size of tank		Throughput	Turnovers
	Bbl.	Ft.	(bbl.)	(times)
(a) Case I	20,000	60 x 40	60,000	3
			200,000	10
(b) Case II	55,000	100 x 40	165,000	3
			550,000	10
(c) Case III	80,000	120 x 40	240,000	3
			800,000	10

Losses on Variable Vapor-Space Tanks

	Case I		Case II		Case III	
	*3 Turnovers (bbl.)	10 Turnovers (bbl.)	*3 Turnovers (bbl.)	10 Turnovers (bbl.)	*3 Turnovers (bbl.)	10 Turnovers (bbl.)
Tank capacity, bbl.	20,000	20,000	55,000	55,000	80,000	80,000
Number of days in service	365	365	365	365	365	365
Throughput, bbl. per year	60,000	200,000	165,000	550,000	240,000	800,000
Annual loss, bbl.:						
1. Breathing	57	57	143	143	198	198
2. Filling	70	234	193	644	281	936
Total	127	291	336	787	479	1,134
Value of loss†	$533	$1,222	$1,411	$3,305	$2,012	$4,763

*Three turnovers were chosen arbitrarily, but might represent a typical condition of use. Obviously, for 0 turnover, there would be only a slight breathing loss. †Does not include replacement cost of membrane.

Conclusion

A comparison of the losses on low-pressure tanks with those on variable vapor-space tanks indicates that the loss on low-pressure tanks is slightly less.

A much smaller variable vapor-space tank, either as an integrated or separate unit, would secure substantially the same savings as the pressure tank at a considerably lower increment of cost over the cone-roof tank. Finally, although the liquid and dry-seal lifter tanks are somewhat more expensive to construct than the flexible-diaphragm type of tank, all past experience has indicated that they are reasonably foolproof in design insofar as major maintenance problems are concerned.

The experience with the flexible-diaphragm type of tank is much less complete, but more experience and probably more development with flexible diaphragms will be necessary before the full possibilities of this tank are realized. For the storage of gasoline and related products in the approximate range of 3 to 10 turnovers, the variable vapor-space tank should be investigated, particularly for application at marketing terminals. Special conditions might warrant even greater throughputs.

In the case of motor gasolines and purely for purposes of general information, the following may serve as an approximate guide: In the range of zero to six turnovers, the variable vapor-space tank is usually preferred and recommended over the cone-roof tank. In the range of zero to three turnovers, this may involve a close decision; but, in the range of three to six turnovers, the conservation tank is usually indicated.

In the range of 6 to 18 turnovers, either the variable vapor-space or the floating-roof tank is recommended. The variable vapor-space tank is usually preferred in the range of 6 to 10 turnovers; and the floating-roof tank, in the range of 10 to 18 turnovers. The floating-roof tank is almost always preferred for more than 18 turnovers.

The low-pressure tank is generally used in the same range of turnovers as the variable vapor-space tank, but is infrequently used in the case of motor gasolines because of its relatively high cost. For products of higher volatility, however, it may represent the only practical type of storage, and an example of this is natural gasoline, or crude oil to which natural gasoline has been added.

Reference

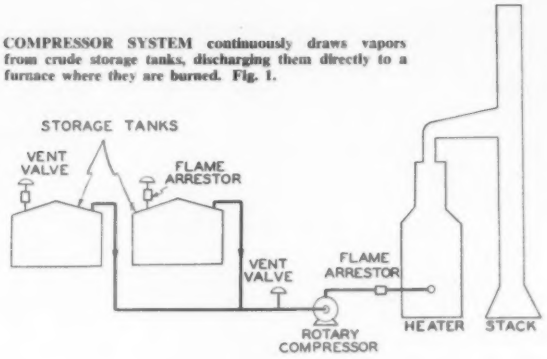
1. Walter F. Rogers, "Method for Calculating Oil Evaporation Losses," Petroleum Engr. 9 (9) 39 and 9 (10) 48 (1938).

Have you a "good neighbor" policy?

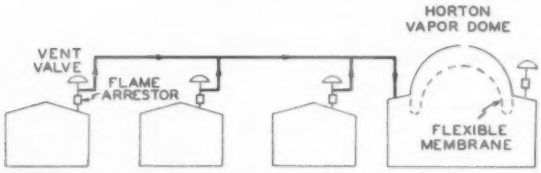
How to Plan a Waste-Disposal Program . . .

in urban areas

by Francis C. Moriarity* and Max M. Fisher*



COMPRESSOR SYSTEM continuously draws vapors from crude storage tanks, discharging them directly to a furnace where they are burned. **Fig. 1.**



GASOLINE BLENDING-TANK vapor spaces are connected with the vapor space of a Hortondome, which has a compensating membrane to receive or discharge vapors as needed in the blending operations. **Fig. 2.**

THE problems of refinery waste disposal have been compounded by the use of modern refining processes which have noxious liquids and gases as by-products.

Among the problems faced by refiners in urban areas are (1) the burning of high-sulfur vapors, (2) the treatment of plant sewer water, (3) neutralization of spent caustic and receiver waste water, and (4) smoke abatement.

The need for exercising utmost care in disposing of refinery wastes goes beyond the individual interests involved. Any laxity in this direction can but reflect on the entire industry.

Refinery Wastes

Waste materials fall naturally into three general classifications, solid, liquid, and gaseous. The handling of each of these encompasses, typically, two phases: first, the steps taken to reduce their volume, or to eliminate them completely; and, second, the ultimate method of disposal.

The solid wastes of normal refinery operation occur primarily as byproducts of the adjuncts used in processing. For detailed information, the reader is referred to the excellent treatises on the sources and extent of particulate wastes in Volume II of the A.P.I. Manual on Disposal of Refinery Wastes.[2]

Liquids . . . Liquid wastes have been amply considered in the available literature. Volume I[3] of the A.P.I. manual is a comprehensive study of the occurrence and control of oil in refinery waste waters. For the more complex problem of removal of sulfides and mercaptans from plant receiver waters and spent caustic solutions, chemical treatment may be required.[6] Also in the instances of need for mechanical separations, such as in the case of emulsion breaking, chemical treatment is often employed.[9]

Gases . . . Because of the volatile character of many products, and because of the use of processes which involve the application of large quantities of heat with their accompanying vapors and flue gases, wastes of the gaseous type are numerous in refineries.

An idea of their extent may be obtained from Armistead,[4] who, in describing plant losses and conservation, gave a brief summary of the variety of factors which contribute to atmospheric pollution. In this lies the key; for the final ultimate discharge to the atmosphere of gaseous wastes, smoke, and suspended particles is the common denominator of the situation.

The release in excessive amounts of anything other than the normal constituents of the atmosphere must be restricted.[2] Thus it becomes apparent, for example, that the total combustion of pure hydrocarbons affords us no pollution problems. It is the impurities in the fuel and imperfect combustion which give difficulty. These appear as contaminants such as smoke, carbon monoxide, and sulfur dioxide.

Even the discharge of pure hydrocarbons from tank-venting systems,[7] process equipment, trucks, and unnoticed leaks, although apparently harmless, may be the medium whereby the odors of constituents in smaller concentrations are intensified to the point where they become a definite annoyance.

Predicted pollution . . . References appear in the literature which predict, with sufficient accuracy, the contamination to be expected from a given set of conditions.[11-16] Sutton,[14,15] and Bosanquet and Pearson,[6] give correlations for dispersion and for ground contamination from stacks. Many instruments are available to measure the actual pollution present.[13] In some cases equipment is available to combat certain problems.

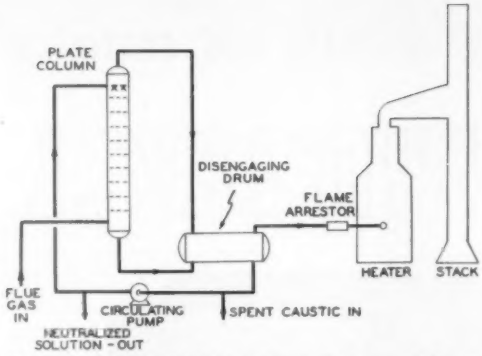
Corrective Measures

It is important to realize, in taking steps to combat waste-disposal problems, the existence of two main ingredients necessary to an adequate approach. Practice has shown that either without the other must fail in the overall effort.

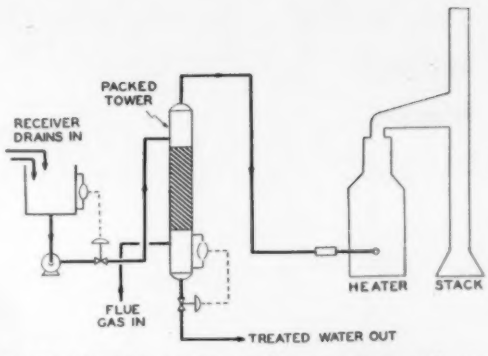
1. Attitude: The attainment of a proper attitude on the part of management and personnel is an achievement greatly to be desired, but difficult to accomplish. The task is time-consuming, and requires a great deal of patience.

First, and certainly of prime importance, is the indoctrination of both employes and management with an honest desire to be good neighbors. By in-

*Aurora Gasoline Co., Detroit. Presented at mid-year meeting of A.P.I. Division of Refining, San Francisco, 1952.



CAUSTIC-NEUTRALIZATION SYSTEM makes use of flue gas from catalytic cracking unit to neutralize spent-caustic treating solutions. Fig. 3.



WASTE WATERS from refinery receivers are countercurrently contacted with a flue gas stream from the catalytic cracking unit. Odorous compounds are removed in the flue gas, which is then burned in a furnace. Fig. 4.

culcating an awareness of and respect for waste problems, we believe the greatest single forward step is accomplished.

Second is an attitude of cooperation with the interested governmental organizations. Today our company solicits the advice, inspection, and counsel of all local bureaus entrusted with the control of industrial influence on public health and safety. Coordination of effort has resulted in the continual growth of understanding and in the respect of our community.

2. Action: Adequate treatment and disposal of our refinery wastes have necessitated many mechanical changes and additions to our refining equipment. We should like to present several of these as examples of possible solutions to problems frequently faced.

1. Crude-oil-storage vapors . . . As in most refineries today, a portion of the crude oil we process is of high sulfur content, containing relatively large amounts of hydrogen sulfide. Crude oil enters by pipe line—avoiding the tank-car venting problem—and is discharged into the refinery crude tanks.

Because these tanks are continuously filling or emptying, the changing volume of free vapor space in these fixed-roof tanks must be vented. When our refinery was small, the amount of this release was too small to be classified as a nuisance. At present, if they were vented to the atmosphere, the gases from this source would cause appreciable pollution.

This condition is avoided by the use of a compressor system (Fig. 1) which draws vapors continuously from these tanks, discharging them directly to a furnace where they are burned.

We should like to call attention to this as a case in point of the benefits to be gained by close cooperation with local authorities. A complaint of discolored paint on the houses in the neighborhood occurred on the day following the arrival of our first shipment of sour crude oil.

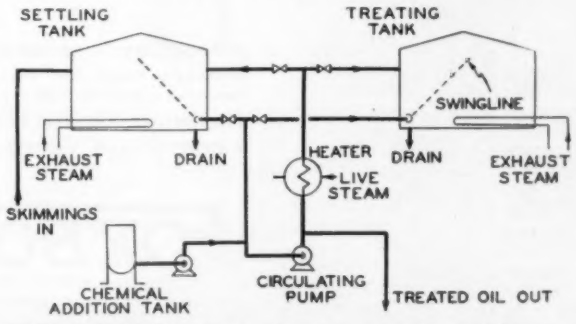
A short rain squall the night before had provided conditions under which hydrogen-sulfide vapors could have caused this difficulty. The joint efforts of our staff and the engineers of the Detroit Smoke Abatement Bureau, who were immediately called, resulted in locating the source of contamination. Within 48 hours the necessary corrective measures had been agreed upon and installed.

2. Fractionator and stabilizer vapors . . . The overhead gasoline from the crude units is condensed under moderate pressure, then charged immediately from the overhead receivers to a stabilizer. Here hydrogen sulfide is removed, by fractionation, prior to rundown storage without the use of caustic. Both the vented receiver gases and the stabilizer gases, both of which contain appreciable quantities of hydrogen sulfide, are burned as plant fuel.

In addition to crude and vacuum facilities, we operate a catalytic cracking unit, a viscosity-breaking unit, a gas-concentration unit, a polymerization plant, and a catalytic reformer. With the exception of gas concentration and polymerization, these processes produce gases which contain hydrogen sulfide and mercaptans. These gases are all handled under pressure, and are burned before discharge to the atmosphere. Some liquid streams are caustic-washed or treated with diethanolamine for hydrogen-sulfide removal.

3. Finished gasoline vapors . . . Vapors from the gasoline-blending tanks are recovered in a Hortondome system.[7] Although these tanks, if vented to the atmosphere, would not release malodorous compounds, inasmuch as they are all doctor-sweet, they would, nevertheless, add a considerable amount of hydrocarbon vapors to the air.

Each of the blending-tank vapor spaces is connected the vapor space of the Hortondome itself (Fig. 2), where a flexible membrane provides a compensating volume to receive or discharge vapors displaced in blending operations. For safety, vent valves and flame arresters are provided in all cases.



AN EMULSION-BREAKING system is used to remove oil suspended in water before the water is discharged to the sewers. Fig. 5.

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This system has reduced gasoline losses sufficiently to show a reasonably short payout; and, in our opinion, it has appreciably mitigated the waste-disposal problem.

4. Flue-gas neutralization . . . Large volumes of flue gas, readily available at a pressure of 15 psi. from our catalytic cracking unit, are used to neutralize spent-caustic treating solutions, thus disposing of what was once a serious problem.[6] In this process (Fig. 3) a batch of spent caustic containing chiefly sodium sulfides, bisulfides, and organics, is reacted with the carbon dioxide of the flue gas.

The chemical action and physical stripping action of hot flue gases on the circulating liquid serves to react, volatilize, and remove the objectionable impurities. The disengaging drum, primarily an extension for the batch capacity of the system, serves also as a knockout pot for the exit gases. These gases subsequently are fed through a steam-aspirated burner to a heater before discharge to the atmosphere. The remaining solution of sodium carbonate and bicarbonate is released to the city sewer.

The waste waters drained from refinery receivers are treated in an analogous manner (Fig. 4). Flue gases are passed through a plate absorption column, countercurrent to the continuous flow of liquid cascading down the trays. The odorous compounds are stripped from the water, thus permitting its safe discharge; whereas the effluent gases are burned in a furnace.

5. Plant sewage treatment . . . Oil suspended in water must be removed before discharge to the sewers. For this purpose we employ an A.P.I. separator[7] and an emulsion-breaking system (Fig. 5). Oil skimmings from the A.P.I. separator are charged to the first tank of the treating system for further clarification, with the use of heat from low-pressure steam coils. Water is drained from this tank.

The skimmings and unbroken emulsion, if in need of additional clarification, are processed in the second tank by addition of sodium carbonate solution and, at times, a patented chemical treating agent;[9,17] then heated with live steam and, finally, settled. Water is drained to the sewers, and the oil skimmings are combined and returned to crude-oil storage.

To avoid contamination of the crude oil with cracked products, a small trap is also operated ahead of the main separator which separately skims cracking-plant drainage. The skimmings are then returned to the cracking-unit flash chamber. The use of the emulsion-breaking system in conjunction with

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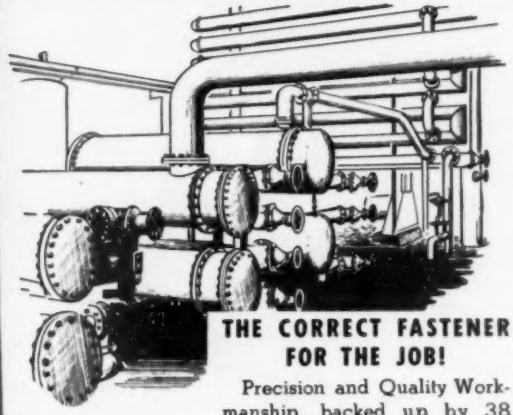

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the A.P.I. separator avoids the accumulation and recirculation of emulsion which would otherwise eventually overload the separator.

6. Smoke abatement . . . In general, smoke occurs most frequently in cases where fuel is burned in amounts which vary too widely and erratically for adequate compensation.[5] For example, process heaters, charged at essentially constant rates, might be expected to be relatively free of smoking difficulties; whereas boilers, whose firing rates depend on constantly fluctuating plant steam requirements, would not. To meet the stringent requirements of municipal smoke regulation, we have installed smoke indicators wherever such trouble is anticipated.

Probably the worst offender in this respect has been the emergency flare system. By design required to relieve and accommodate relief gases from multiple varying sources, such a system may be called upon to handle momentarily a thousandfold increase. Our vapor-relief headers are all connected to a separator which is equipped with automatic level control and a pump whereby most of the entrained or condensed liquid may be recovered; thus liquid discharge to the flare is prevented and appreciable amounts of liquid hydrocarbons recovered.

The flare itself remains a serious problem. Recently we installed a new, rather complicated system of steam-aspirated burners to provide the required amount of air for any flow condition. Inasmuch as the allowance velocity of injection for flare gases is restricted by the requirement of negligible back pressure, steam was to be used in automatically regulated amounts for the purpose of inducing the necessary draft. The system was not satisfactory.

Compressor failures, shutdowns, and emergencies cause such extreme variation, in both the volume and heating value of the gases, that the system is unable to compensate rapidly enough. We find that under a single, given set of conditions, this unit might function well but that, over so wide a range, actual physical redesign would be required. Unfortunately, the situation is aggravated by the production of a thick, black smoke, when it smokes at all. We have, therefore, returned to the use of the conventional brick checkerwork open flare.

Conclusions

The writers find the A.P.I. Manual on Disposal of Refinery Wastes, in all respects, both useful and informative. It is, however, maintained that only Volume I, which pertains to the treatment of refinery waste waters in the A.P.I. separator, is adequate.

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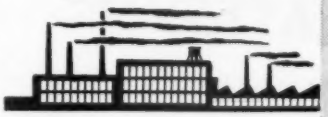

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It is the writers' contention that, ideally, the manual should present the carefully weighed conclusions which result from the collective thinking of the entire industry. The method of presentation of these solutions must be such as to provide a format of engineering data and design readily adaptable to individual requirements and acceptable to regulating authorities. The combined experience of the industry as a whole would then afford a responsibility which, together with the recognized approbation of the Institute, would tend to insure the almost automatic approval of regulating bodies.

The industry-wide acceptance of the A.P.I. separator is a tribute testifying to the efficacy of Volume I and the adequacy of the coverage provided by this type of presentation. Comparable treatment of the material in those volumes which follow would be in reasonable anticipation of similar acceptance of their recommendations. At present these volumes, although of much interest, are predominantly in the character of general textbooks which cover their respective subjects by means of generalities.

The suggestion of a number of remedies — which, undoubtedly, have already occurred to many readers—unfortunately is insufficient. It is the writers' recommendation that these volumes be amplified by actual engineering data and typical details to render them far more useful as solutions for refinery waste-disposal problems.

There exist other problems common to many refineries. Only the consent and encouragement of the members of the A.P.I. Committee on Disposal of Refinery Wastes are required to initiate studies ultimately to result in additions to Volumes II and III of the manual. In particular, two are recommended for immediate consideration: (1) waste-gas disposal; and (2) spent-caustic treatment.

The ever-increasing publicity being given to air pollution has indicated the need for an exhaustive appraisal of this entire subject if we, as an industry, are to move rapidly enough to avoid serious public reaction. Newer methods of analysis and apparatus for detecting air pollution in minute amounts have greatly reduced the value of distance as a protective feature.

We are all aware, for example, of the distances over which aerosols discharged to the atmosphere may travel in concentrated form. Carelessness with regard to atmospheric pollution, and eventual serious harm to our industry through public indignation, are the only results of the false complacency which distances give us.

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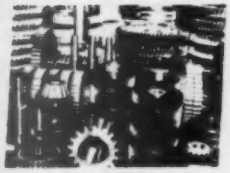

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is even less of a protective measure. The careless disposal of waste caustic solutions or other chemical wastes by any refineries will serve only to strengthen the case of those who would have restrictive controls placed on our industry.

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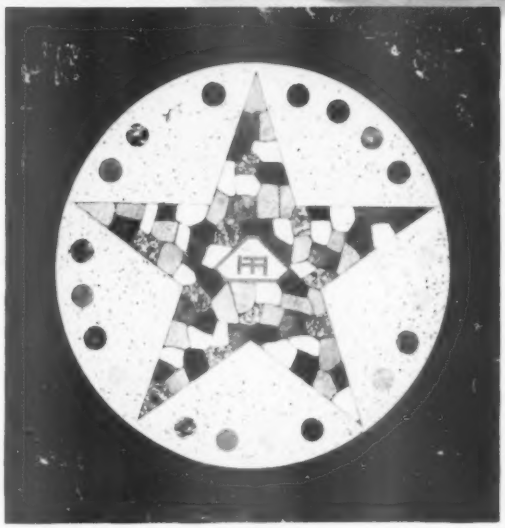
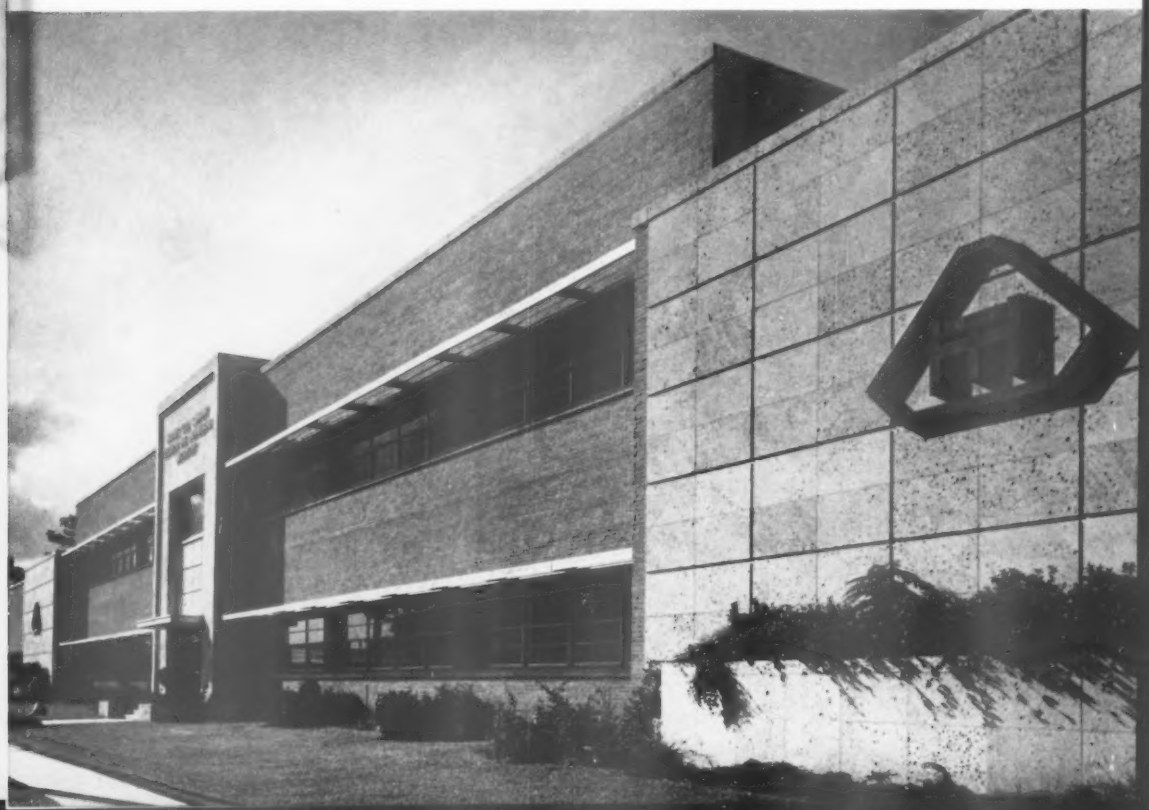
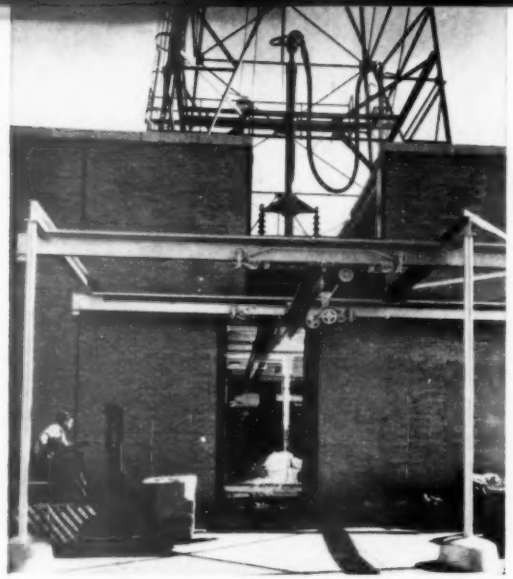
Six laboratory sections and a modern machine shop are housed in the Research and Engineering Laboratory building. These are: Drilling, Product and Product Part Mechanical Testing, Metallographic, Chemical, Heat Treating, and Welding. The building is of brick and stone construction and is 325 ft. long, 120 ft. deep with a two-story center section. The total floor area is approximately 60,000 sq. ft.

Research, of course, is not new at Hughes. The industry's and world's first "drilling research laboratory" — to study the performance of rock bits — was established by Howard R. Hughes, Sr., in 1910. In recent years the laboratory facilities have been repeatedly expanded, culminating in the building of the new laboratory, regarded as the finest of its kind, devoted to the drilling industry.

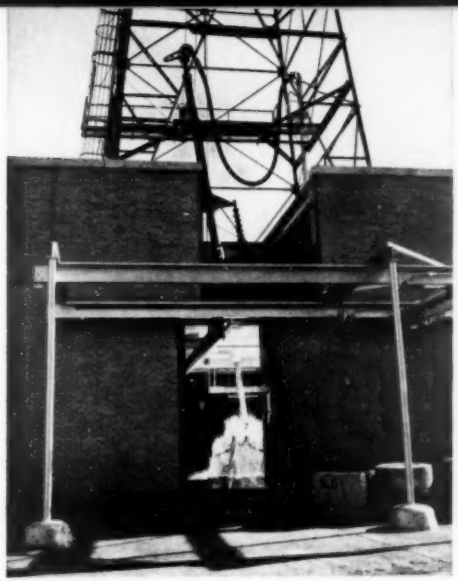


The decorative star-shaped insert in the center of the lobby floor is an arrangement of rock pieces from formations used for drilling tests by the Laboratory. The 20 round pieces between the points of the five-foot star are sections of cores obtained from major oil producing areas of the United States.





In this view of the drilling rig are shown derrick, swivel, drill stem, "V" window, hydraulic pulldown yoke for applying load on the bit, and "cellar" — the laboratory room in which test blocks are drilled. The derrick rising above the Laboratory roof is 118 ft. tall.



Inclined drilling is one of the many special investigations carried on with the Laboratory drilling rig. In these tests the drill stem can be inclined as much as 10 degrees. This type of experimental drilling has furnished valuable information relative to the problem of straightening crooked holes.

FIELD-SIZE DRILLING RIG USED IN LABORATORY DRILLING

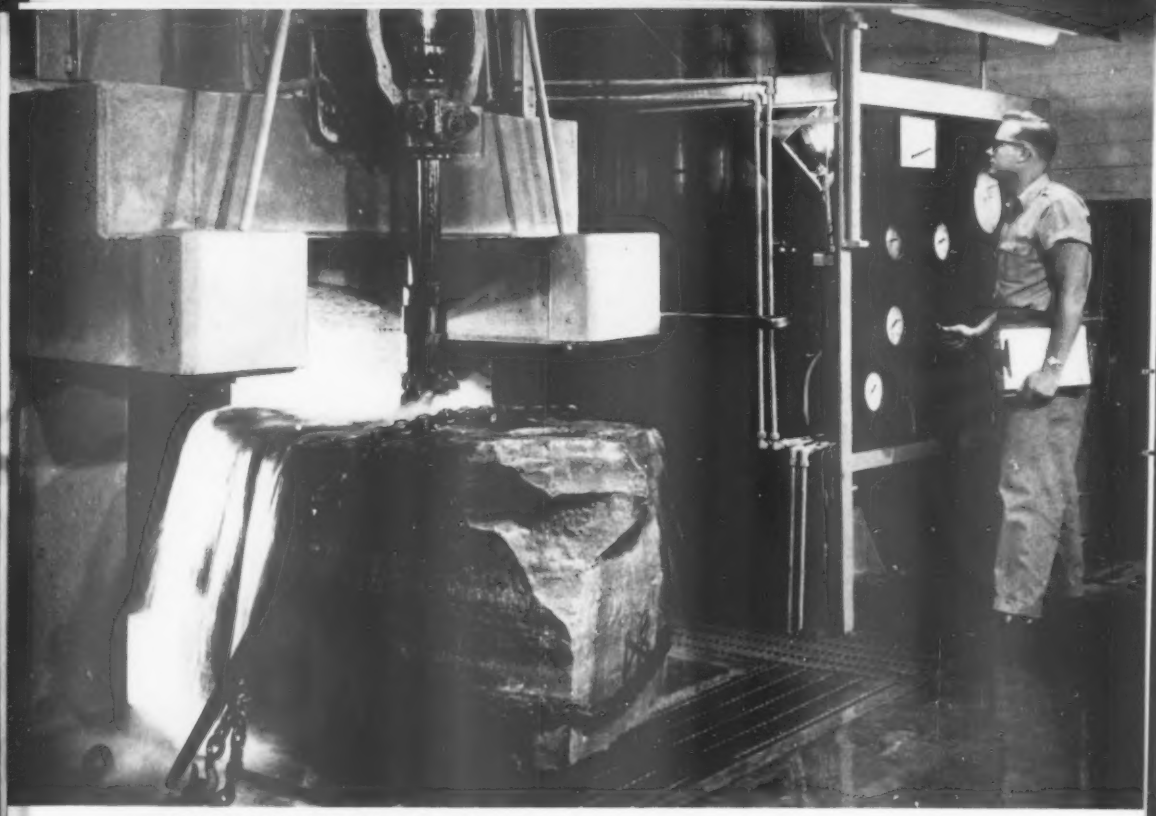
The fundamental purpose of all Hughes rock bit research is to improve rock bit performance.

In attaining this improvement it is necessary to balance design with the application of correct metallurgical materials and processes.

The preliminary proving ground is the Drilling Laboratory housed within the main Laboratory building. Its field-size drilling rig, with 118 ft. derrick, was specially designed to test rock bits in a manner simulating oil field drilling conditions. Variable drilling loads as high as 100,000 lbs. can be applied to the bit with rotational speeds up to 400 R.P.M.

Test blocks of rock, used in these drilling tests, are taken from many states throughout the country and are selected to approximate the drillability of formations encountered in the various oil fields. These test blocks are used to evaluate designs, materials and metallurgical processes.

Drilling is controlled by an operator seated in the booth shown above the test block. The rotary table that drives the drill stem is located on the "deck" of the rig at a level corresponding to the working floor of a field rig.

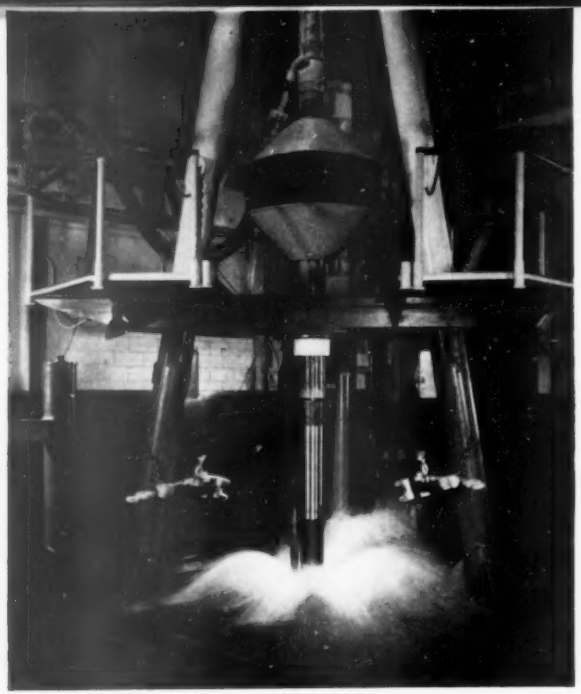


AUXILIARY DRILLING RIG. This small rig is capable of applying loads up to 50,000 lbs., at speeds up to 90 R.P.M. The operator in the above photograph is starting a hard formation drilling test and is studying the readings of a drilling rate indicator. A Hughes development, the indicator tells the operator the actual rate of penetration being made by the bit, instantly indicating every change in progress.

MICROBIT USED IN ESTIMATING ROCK BIT PERFORMANCE

The Microbit shown here is 1¼" in diameter. It is used in drilling cores and rock samples from all parts of the world.

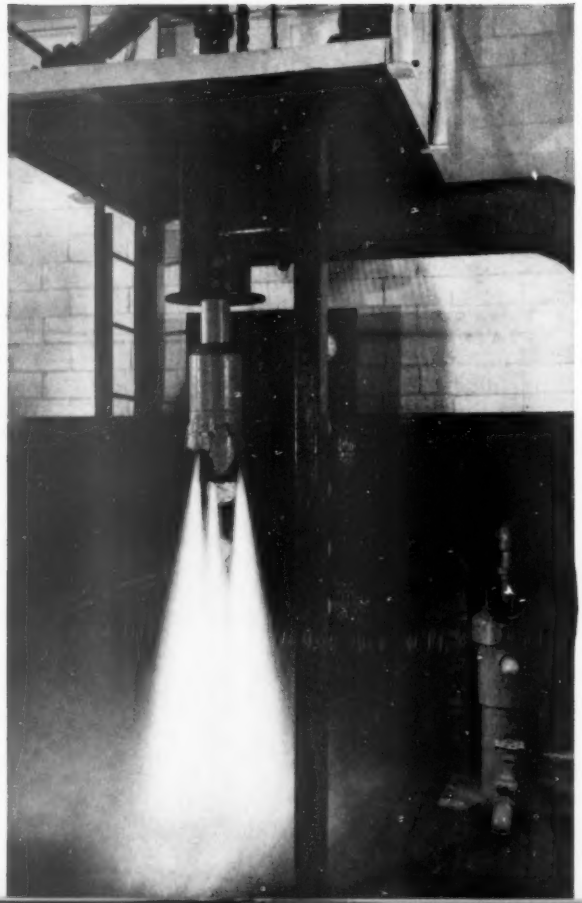
Examination of the data obtained during the microbit drilling gives Hughes engineers information for estimating the performance of full-size bits in the same type of rock formation. The microbit drilling tests provide a good basis for picking the proper type of bit to be used in specific formations and in recommending the operating conditions that will give the best results.



PERCUSSION DRILLING TEST EQUIPMENT

The Drilling Laboratory is equipped to test new drilling techniques as well as new tools. The test equipment shown at the left was designed primarily for use in the development of rotary-type percussion drilling tools and bits.

At the time this photograph was taken a time-displacement diagram was being made to determine the cyclic characteristics of a fluid-actuated percussion tool. The entire "A" frame is supported on a reinforced concrete foundation mounted on large helical springs to reduce vibration.



TESTING HIGH VELOCITY JET BIT

In the development of Hughes jet rock bits emphasis has been placed on high velocity jetting action and bottom hole flow pattern.

The photograph at the left shows a test being conducted to observe the action of various types of jet nozzles.

The pressure drop across the bit and the velocity of the drilling fluid are important factors affecting the penetration rate of the bit. It is necessary that the fluid jets have sufficient velocity to remove the cuttings from bottom and keep the cutters clean.

The pressure assembly at the right in the photograph is used in studying fluid jetting action of individual nozzle outlets on various formations.

STUDY OF "DULLS" AIDS IN THE ADVANCEMENT OF DESIGN AND METALLURGY

The cycle in the study of new bit designs, materials, and processes of manufacture is not concluded until bits used in the field have been returned to the Laboratory for inspection by Research, Product and Metallurgical Engineers.

Combined with the laboratory tests, field trials predict the performance of new materials, processes, new bit design or a design change in a standard bit. Trial groups of bits are run under the observation of Hughes field engineers who return the "dulls" to the Laboratory along with the complete performance record of each test bit.

Project studies of this type are regularly conducted in many areas on large groups of bits involving several sizes and types. The returned bits are examined externally and then disassembled for a thorough physical and metallurgical study. Information from these sources provides a reliable basis for engineering evaluations.

Section of Laboratory showing Hughes engineers examining returned bits together with their field performance records. This is a continuing study carried on throughout the year.

Above, the shop foreman is explaining to the lathe operator machining details on an experimental cone. Below, teeth are being milled on an experimental cone.

LABORATORY MACHINE SHOP MANUFACTURES TOOLS FOR FIELD TESTS

The Hughes Laboratory Machine Shop is devoted to the building of full-scale test models of rock bits, tool joints and other drilling tools for laboratory and field testing. In connection with the latter, this Shop is equipped to expedite the manufacture of these tools in sufficient quantities for extensive and immediate field trials.

The Machine Shop handles a large amount of work for the Research, Product and Metallurgical Engineering Departments in building new designs, new mechanisms and new devices requisitioned for preliminary testing or other experimental work.

The operator, above, is preparing to remove experimental bit cones from an atmosphere controlled heat treating furnace for quenching.

Controllers and temperature recorders for the Laboratory heat treating and carburizing furnaces.

COMPLETE LABORATORY HEAT TREATING FACILITIES

Metallurgy plays a major role in the development of new drilling tools at Hughes and in the improvement of existing tools. As a result, special emphasis has been placed on heat treating, carburizing and atmosphere control equipment in the new Laboratory. These facilities, under the direction of the Metals Group, are used principally for the heat treating and carburizing of experimental products and product parts for laboratory and field testing, and for setting up and maintaining proper controls over metallurgical operations employed in the various production shops in the Hughes plant.

With the Machine Shop to make experimental product parts, together with complete facilities for carburizing, heat treating and other metallurgical processing and the various mechanical and physical testing equipment, valuable technical information can be obtained rapidly and with controlled accuracy.

Technician transferring high temperature pot, loaded with cones, from gas carburizing furnace to slow cooling unit.

Extent of hard facing and welding facilities is shown in this view of the Welding Laboratory.

Operator applying tube tungsten carbide to the surface of a Hughes "Flash-Weld" tool joint box.

WELDING LABORATORY ADVANCES HARD FACING & WELDING TECHNIQUES

The Hughes Welding Laboratory is equipped to do the hard facing and welding required on experimental tools, conducting investigations of new hard facing materials and techniques, handling the control work on materials and equipment used in shop production welding, hard facing and brazing operations, and carrying on other work normally requiring the use of this type of equipment.

Tube tungsten carbide (Hughesite) is being applied to the teeth of Hughes rock bit cone.

Starting an experimental hard facing job, the welding technician and engineer are selecting required hard facing alloy rods from laboratory-manufactured stock.

Metallurgist prepares for a microstructural examination of a bit tooth section on the metallograph.

The stereoscopic microscope is used to aid visual examination of metal parts where relatively low magnification is desired.

Tukon hardness tester used in measuring Knoop hardness of miscroscopically small areas on finely polished metal specimens.

The hardness of a section of carburized and heat treated Hughes rock bit cone is being measured with a Rockwell hardness tester.

COMPLETELY EQUIPPED METALLOGRAPHIC LABORATORY

The complete array of instruments in the Metallographic Laboratory along with a unique macro-etching installation, designed by the personnel of this group, and a modern, highly efficient dark room arrangement enlarge the scope of work that the Metals Group is prepared to undertake.

The instruments here include latest types and models for the advanced nature and large volume of metallographic work handled by this group. Special emphasis is placed on the importance of hardness measurements and microstructural studies of extremely hard materials (the diamond substitute types) that play such an important role in oil well drilling.

High speed photography is employed to analyze rock bit drilling action and other rapid motion phenomena.

In addition to investigating new materials, and processes, the Hughes Metals Group devotes a substantial part of its time to routine laboratory operations related to metallurgical materials and process controls involved in the Company's manufacturing operations.

Boron analysis is routine step in controlling quality of abrasion-resistant alloys made by Hughes.

The manganese content of a steel sample is being determined in the titration with sodium arsenite.

Combustion type furnaces used for the determination of the carbon content of steel.

General view of the Chemical Laboratory taken during the running of various metal analyses.

CHEMICAL LABORATORY PLAYS IMPORTANT ROLE

The Chemical Laboratory, as set up in the new Research and Engineering Laboratory building, performs a dual role. Its facilities are used to advance the search for new materials to meet the requirements of new products and new uses, and to establish and maintain controls over plant operations.

In the latter capacity, the Laboratory's comprehensive analytical program makes possible the maintenance of high product quality in production carburizing and hardening, as well as the many other metallurgical operations and processes involved in the manufacture of Hughes Tool Company products.

The Laboratory is equipped to handle a wide range of analytical procedures. Among its specialized equipment is the latest type direct-reading spectrometer used for rapid production analyses and for the determination of elements that would be time-consuming under other analytical procedures.

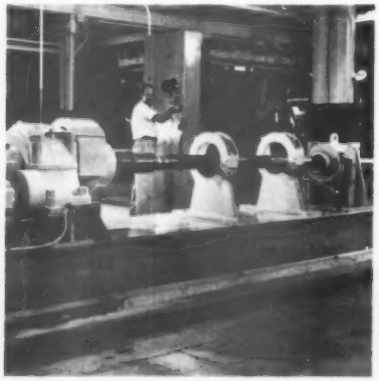
PRODUCT COMPONENTS UNDERGO SEARCHING TESTS IN MECHANICAL TESTING LABORATORY

The Mechanical Testing Section and the Project Engineers assigned to this work are largely concerned with testing product parts or product assemblies under conditions simulating oil well drilling. Many of the Laboratory machines are designed by the group to approximate the conditions that will be imposed on the part or assembly in actual service.

The mechanical testing equipment includes a high capacity torque measuring machine, machines for fatigue testing full-size drill stem connections, machines to test resistance to abrasion, and machines designed and built to test antifriction bearings and plain bearings under variable loading and rotational speeds while being flushed with an abrasive-ladened fluid to simulate drilling mud.

The ultimate objective in these specialized tests is to improve the service life of the product by determining the materials and designs that assure the best results.

600,000 pound-inch torque measuring machine used in testing drill stem components such as tool joints, drill collars, drill pipe, pin and box connections and tool joint-to-pipe connections.

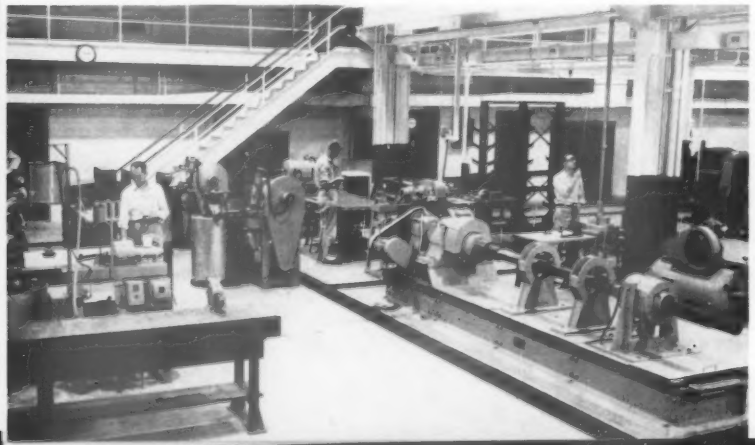


Rotating cantilever beam type fatigue machine used to test tool joint-to-pipe connections. A bending load is applied by an air cylinder that sets up cycles of reverse bending as the specimen rotates.

Testing the abrasion resistance of the gage surface of a rock bit cutter.

Bit bearing abrasive wear tests indicate the ability of bearings to stand up under severe drilling conditions.

Pictured below is a portion of the area devoted to specialized mechanical testing.



The Williston Basin . . .

Today's newest, most exciting oil province

by S. F. Bowlby*

Here's an appraisal of the significance of this area, with regard to the national supply situation. Also discussed are general characteristics of its geology, and its development

THE Williston basin is located in the western part of the Dakotas, eastern Montana, southwestern Manitoba, and southern Saskatchewan. Its area is variously estimated from 80,000 to 240,000 sq. miles. The reason it is not more closely delineated is that there is no real geologic barrier between it and the great Alberta basin, which includes the prolific fields of Alberta and extends northward into the Fort Norman area. It is the largest basin of sedimentary deposition favorable to the accumulation of oil on the North American continent.

The sedimentary section of Williston basin reaches a thickness of approximately 12,000 ft. in its deepest part. This centers roughly on the Montana-North Dakota border and includes a nearly complete section of Mesozoic and Paleozoic strata in which numerous reservoirs, present and productive in the other oil-producing provinces of the North American continent, now are being rediscovered here.

The physiography is that of the Great Plains and the eastern slope of the Rockies. Thus, with the exception of one or two surface features, such as the Baker-Glendive anticline, it is largely featureless so far as the surface is concerned. The area responds well to the customary exploration tools. The seismograph, for instance, is being fully exploited. More seismograph crews have moved into the area than into any other place in the country. The actual drilling conditions are not unusual nor overly difficult, and compare favorably with West Texas.

The current exploration and development effort of the industry, which is reaching boom proportions, was triggered by the successful exploitation of the Leduc and Redwater areas farther north in Canada. However, it is significant that long prior to this time, oil men, with their customary penchant for looking over the next hill, already had drilled hundreds of wells in the area. Forty years ago gas was discovered in some of the shallow wells. Others were rank exploratory wells and, in many cases, uncovered not only satisfactory reservoirs, but significant shows of oil. Thus, we have all the requirements of a good oil province, viz., ample petroleum stratigraphy, structure that can be developed by conventional exploration and drilling methods, and reservoirs with ample signs of petroleum accumulation.

*Shell Oil Co., Los Angeles. Presented at thirty-second annual A.P.I. meeting, Chicago.

Geography and Climate

On the other side of the coin, factors pertaining principally to operations and attendant costs require consideration. Climatic conditions are rigorous; and in winter, when the temperature may reach 40° below zero, operations are being carried out sometimes with great difficulty. The area is sparsely populated with but few large towns in which to headquarter. These, we are learning, have inadequate facilities to meet the tremendous burden imposed on them by the rapid growth of the industry's operations. Consequently, there are few supply points, and transportation and communication are more difficult than in most other places in the United States. All this leads to higher than normal operating costs, although I am gratified to see that in the areas being developed, we find a repetition of our experience elsewhere, viz., these costs decrease as experience and know-how increase.

Aside from the climatic conditions, which probably won't change, our experience here seems to be no different from that in early stages of many another oil-producing province. Further, exploratory and development drilling has shown several anomalies which, while somewhat disturbing, are certainly to be expected. For example, oil is now being produced from limestones and dolomites of Mississippian, Devonian, and Ordovician age in the United States, and also from Cretaceous and Jurassic sands and limestones in the western Saskatchewan portion of the basin. Nevertheless, these formations, although present throughout the area, are not all productive at any one spot, even though structure sufficient to enclose a sizable quantity of oil may be present in each. There is a wide divergence in the character of the limestone and dolomite reservoirs. We see the type of accumulation which characterized the Michigan development, and also the prolific sugary dolomites of West Texas. However, much remains to be learned about the area.

Thus far I have dealt with the Williston basin in its broadest geographic extent. However, I believe you are most interested in that portion in the United States, so my remarks now will pertain to only that part of the basin.

Coming back to the significance of the Williston basin, April 1951 was really the beginning of time so far as the area is concerned. Since then, there have been about 75 new field wildcats drilled in the United States portion of the area. These have resulted in 13 discoveries of one sort or another. This success ratio is one in six. The experience in the United States as a whole during the last 10 years is one in nine. So it is evident that there has been a much higher success ratio in the Williston basin than one would normally expect in a new area.

Drilling Activity

At present in the area there are 80 drilling rigs and 120 seismic crews. And the total personnel in exploration and production is estimated at 6,500. When one reckons into the whole bill, the cost of acquiring land, we find that the industry is currently spending about $100,000,000 a year in the area. Some authorities have estimated that the total bill to date is about $200,000,000. I would estimate also that about 80 per cent of the potential area is now under lease in one way or another. These facts show, I believe, that in the judgment of the industry as a whole, the Williston basin constitutes a major province. This conclusion seems valid even though at this time only a small portion of the territory has been explored by the drill.

Most of the fields discovered so far in the area are on one or the other of two great anticlinal trends—the Nesson anticline in North Dakota, and the Baker-Glendive or Cedar Creek anticline in Montana. One of the fields, Beaver Lodge, located on the Nesson anticline, encompasses probably 25,000 acres. Fifty oil wells have been completed in this field. Their total potential is much greater than 10,000 bbl.

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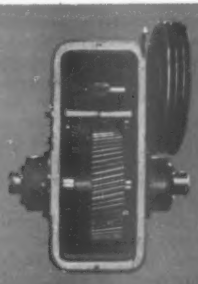

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per day. Current production from the field is about 7,000 bbl. per day, being limited somewhat by the market outlet presently available. Development of the other fields on these anticlines has not gone far enough to show their magnitude, but indications are that some will be of major importance, whereas others will have substantial reserves. In this regard, it's interesting that a gross producing interval of 500 ft. was demonstrated in one well near Glendive, Montana.

The quality of the oil discovered thus far is that of good light refining crude, ranging in gravity from 30° to 44°. Production characteristics vary with both flowing and pumping completions, and production seems to be obtained by the water-drive mechanism in many cases. The oil may be characterized by an undersaturation of gas, although the Beaver Lodge Mississippian pool has a normal gas-oil ratio of approximately 1,000 cu. ft. per barrel, and a deep Devonian zone tested by the discovery well at Beaver Lodge has a gas-oil ratio of 9,000 cu. ft. per barrel.

The current production of the basin, which is about 10,000 bbl. daily, is not being entirely absorbed by the local market. Major pipe lines are several hundred miles distant. Thus, it is evident that, as the area grows in importance, transportation and refining, with their enormous capital investments, will present substantial problems. We cannot now do much more than speculate on the time when Williston basin will become an important part of the nation's oil economy. One might try and make such a guess by comparing it with other now-important producing areas. But any comparisons of this nature, I feel, are untenable because it is impossible to reconcile the many variables. For instance, in Alberta—part of the same province—substantial quantities of oil have been produced for more than 30 years. It was not until 1949 that the supply exceeded local demand so that the impact of its production was felt on the Canadian and United States overall picture. Also, exploration in Alberta was then much less intense than the current program under way in the Williston basin. This is speculation, but I believe that within 5 years, or by 1958, it is within the realm of possibility that oil production on the United States side of the basin may reach 100,000 bbl. a day.

The strategic importance of the geographic location of the Williston basin—almost equidistant from the big markets of the Midwest and Pacific Northwest—should not be overlooked. Current thinking of industry seems to lean strongly toward an eastward move-

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ment, at least in the initial stages. I do not think that this movement will disrupt the Mid-Continent supply position, but rather will have a beneficial effect on it. This would hold also in the California situation—in the event supplies of sufficient quantity are developed to justify movement in both directions. Several operators in the area already have announced plans for constructing transportation and refining facilities on the United States side of the basin.

Since the flood tide of exploration in the Williston basin seems to continue, it might be well to do a little more speculating about the kind of venture in which the industry is engaged as it pertains to the cost of finding an oil field. There are several ways one can go about this, but for simplicity's sake, let's assume that in a major exploration program the costs of exploration work, land, and wildcat drilling are equally divided. Over the long pull, I believe you will find that this division has some historical basis. With the wildcat-drilling cost in excess of $300,000 per well, you can see at once that it takes approximately a million-dollar investment to find any single prospect.

The success ratio in the Williston basin does not agree with the national picture. It is probably on the high side. A more reasonable estimate, or at least one that more nearly conforms with the national picture, would be a success ratio of 1 in 10. Thus, extending our estimating a bit further, it would appear that to discover an oil field, an over-all expenditure of about $10,000,000 is required. In these assumptions, I am not unmindful of the success ratio developed by F. H. Lahee, of the American Association of Petroleum Geologists. Lahee determined that only 1 out of 44 new field wildcats discovered a field of more than 1 million barrels ultimate, and only 1 out of 967 new field wildcats discovered a new field of more than 50 million barrels ultimate.

All in all, it is apparent that a major exploration program in this area is a blue-chip venture, and that the ultimate stakes must be high enough to justify the risks for what the attorneys call "a reasonably prudent businessman."

BOOK

AUTOMOTIVE FACTS AND FIGURES. Thirty-second edition. Published by Automobile Manufacturers Association, New Center Building, Detroit 2. 80 pp.

This new edition contains a number of studies of the automotive industry hitherto unpublished. In the field of taxation, an analysis shows there is $650 in taxes in a $2,000 passenger car delivered to the customer ready to use. Many will find this booklet a useful and interesting compendium of facts.

How to Train Supervisors

There is no best way to conduct a formal program of developing supervisory personnel. It's a job of tailoring to fit a particular set of conditions.

by Frank H. Willibrand*

THERE is controversy in industry over the manner in which a formal supervisory-development program should be conducted. It is to be concluded that a satisfactory program may be conducted either by line or staff or a combination of both, so long as there is general acceptance of the program by all in the top and middle management groups. Any successful program must be planned with painstaking care to fit the needs of the particular organization under consideration and the program must be projected for a long term.

Previous paper . . . At the A.P.I. meeting in 1949, George B. Corless (Standard Oil Co., New Jersey) gave a paper[1] before a Division of Production group session. He defined executive development as "an effort to apply the same principles of management; that is, planning, organizing, directing, coordinating, and control through selection and development of management personnel, which are used in the physical and financial phases of a business, in contrast to the haphazard methods based on the hope that the cream will come out at the top." With the substitution of a few adjectives, his definition concisely states the case for supervisory development.

Perhaps it is well that Corless' paper preceded the one now being given because any successful supervisory-development program must have wholehearted acceptance and support of the top people in any organization in which such a program is being carried on. It is, however, also true that an executive-development program is quite likely to be more fruitful if it has been preceded by an effective supervisory-development program. There is no intent here to draw a fine line of distinction between an executive and a supervisor except to say that a successful executive must have, in addition to certain recognized managerial skills, at least the basic skills, disciplines, and philosophies of the successful supervisor inasmuch as each directs the efforts of others.

Program development . . . In exploring this subject we might inquire, (1) why should an organization have a supervisory-development program and, if so, (2) of what should such a program consist, and (3) how should the program be conducted? If an organization is in the process of answering question (1), it might be well for it to first set forth the objectives sought. If there is agreement within an organization regarding the objectives, there should be no major obstacles in gaining acceptance and support once the program is under way. However, if agreement on sound objectives is not possible, it would appear advisable to delay adoption of any formal program.

A supervisory-development program may be broken down into four major areas of training: (1) in new and evolving technology; (2) in company methods and procedure; (3) in basic economic concepts; and (4) in human relations. As will be observed, there is no direct relationship between these four areas of training. In delineating the objectives sought in a proposed program, consideration should be given to designating areas of training which will be given major emphasis.

There is some doubt that a sound program for technological development of key personnel in a producing organization may be carried out unless the supervisors in question are relieved, for an extended period of time, from all company duties. Our colleges and universities are, for the most part, doing a good job in training students in the sciences of engineering, geology, and geophysics. With the foundation acquired by apt graduates, each is at least in a position upon leaving school to keep up with ever-changing technology through continued study.

To attempt to impart technological understanding to an individual burdened with a full work load is a most difficult undertaking. It is not implied here that every supervisor in our business must have a technical education. All of us know able supervisors who have not been to college. Some of these may be helped by being sent to school to study basic technological subjects.

Effective supervision . . . An effective supervisor must understand company methods and procedure. Standard practice manuals are helpful for background but the application of standard practice to the job at hand is learned by doing. To illustrate: An ardent student would find it impossible to drill a well with present-day equipment, even though he had exhaustively studied a comprehensive drilling manual, unless he first learned the application of the methods outlined in the manual by working for a long time on an experienced driller's crew. Day-to-day work on specific assignments under an experienced supervisor willing to teach and train an understudy has always been an effective means of expanding a pool of potential supervisors.

An understanding of basic economic concepts is not gained in 10 easy lessons. As our civilization becomes more complex, the tendency for the actions of government to impinge upon the economics of any business becomes more manifest. We hear a great deal about hard dollars and tax dollars; yet many who use these terms have little understanding of their interrelationships or fully realize the significance of the rather unpredictable nature of our national tax structure.

Economics by some is called a science and, if so, may lend itself in part to the same kind of analytical dismemberment as does, for instance, engineering. By the same token, a good understanding of this science if such it be may not, in my opinion, be gained by attendance at infrequent lectures or by perusal of treatises of some phases of economics. It would be just as preposterous to assume that the foundation for sound engineering could be laid by a study of Popular Mechanics.

Understanding of the application of economic concepts to specific problems may be achieved through a series of conferences conducted by one thoroughly familiar with the subject. Some companies have taken their annual statements to supervisory groups and have effectively helped these supervisors to a better understanding of the true significance of the balance sheet and profit-and-loss statements.

Human-relations training . . . Benefits to be expected from supervisory training in technology, economics, or in company methods and procedure may be relatively minor in nature. It may be that adequate training in human relations will make effective training in technology, economics, or in com-

*Sohio Petroleum Co., Oklahoma City. Presented at Thirty-second annual A.P.I. meeting, Chicago.

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pany methods and procedure easier to accomplish. When considering a supervisor's job the superior-subordinate relationship must be examined.

The attitude that a supervisor has regarding this relationship may, more than anything else, determine the effectiveness of his supervision. Every supervisor should ponder this relationship long and often. Acquisition of skill in human relations must, in the opinion of many, be based on acceptance of the golden rule.

Of ancient origin [2] is the contention that human cooperation is achieved only in a spirit of humility and good will. If we could remove the obstacles that prevent people from doing their best, the magnitude of the potential thus released staggers the imagination. All may agree that the day of the boss who got compliance through fear is over. We no longer see many work gangs directed by one chosen to do so simply because he could "lick" any member of the gang. Further, the fear of immediate discharge can no longer be considered as the impelling motive, if it ever was, for adequate performance by the worker.

Anything we may do to increase the productivity of the individuals in our organization will increase the profitability of our business. There is, or should be, little quarrel that increase in profitability is beneficial to all who are associated with the business. Many recognize a close relationship between job satisfaction, competent supervision, and production on the job. One overall objective of a supervisory-development program might well be to improve present performance and to create an adequate reserve of supervisors. A supervisor may say the right things but unless he also does the right things, his influence on those whose work he directs may be mostly negative.

In June of this year, the Harvard Business School's Twenty-second National Business Conference had as its theme "Getting People to do Things." Dean Davis of the school stated that "providing the conditions within which people will themselves decide to accomplish as much as they can is more fruitful than getting people to do work despite unremoved obstacles." Phillip D. Reed, board chairman of General Electric Co., says that organizations designed for iron men and geniuses are not for the long pull.

Jervis J. Babb, board chairman of Lever Brothers Co., at the conference referred to, asked, "Why do boards of directors insist on approving capital expenditures, say for a machine tool costing $10,000 with an expected life of 10 years and at the same time pay little attention to the man who may

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Supervision has been defined by some as the art of handling people. The dislike I share with others of this definition may be more than mere quarrel over words. "Handling" denotes manipulation. Rather, I prefer to think of supervision as the art of handling one's self in one's dealing with others. Further, in one's dealing with others there must not be even a subtle hint of force or fraud.

Employe needs . . . Employes have certain basic needs, other than monetary reward, all too often overlooked. Some of these are recognition, security for family, belonging, and an opportunity for growth. Jack Jones may be a lease pumper on the Slickenstein farm north of Podunk, but also he is an individual who continually strives to be recognized as such. He is motivated by his habits and beliefs, his ideas of status and code behavior, and his basic attitudes and assumptions which may or may not coincide with those of the pumper on the adjoining farm.

If it appears that he is more loyal to his union than to his company, the underlying cause may not lie entirely with Jones. If the affairs of the union are not being conducted to his liking, he can at least give expression to his objections without imminent fear of recrimination. The tendency for Jones and others to look to the union as a safeguard for opportunity for growth may have come about through their own observations. If Jones has rightfully or wrongfully reached a conclusion that he has not or will not be given a fair deal in any promotions, it is quite normal to expect him to look to his union to protect this right through seniority alone.

It answers no questions to say that Jones has a bad attitude. If what is called a bad attitude has been observed in Jones, it may be a symptom of some more basic cause unless Jones is a crackpot and recognized as such by his fellow workers.

Even though hundreds of articles have been written on the subject, there is no common pool of knowledge on how to be a good supervisor. There runs through the literature, however, at least one central theme and that is that every good supervisor is required to be a good listener.

Being a good listener means, among other things, giving undivided attention to the individual who is or feels aggrieved in an atmosphere where the employe feels at ease. The listener should not attempt to give direction to the conversation but should, with interest and sympathy, make every effort to understand what is being said from the point of view of the teller.

We implied that today's supervisor gains his objectives through leadership. Adequate leadership is honest and understanding. It welcomes more democracy in industry and reaches full stature only in those who never forget the essential dignity of man. It also requires the courage to take decisive action when all else has failed. A supervisor who has been chosen because he was the best craftsman in the gang may be ill equipped, without specific coaching and training, adequately to do that job.

Management support . . . In the foregoing we have attempted to show why there should be a supervisory-development program within an organization. Also, we have indicated in part what such a program should consist of. Stated in another way, such a program should be a planned and organized effort in the training and selection of those in an organization who direct the work of others. You will note that this includes all levels of management. Emphasis must here be placed on the point that unless any program has the active support of the entire hierarchy of management, it is doomed to failure.

If, as Virgil K. Rowland (assistant to secretary and general accountant, Detroit Edison Co.)[2] suggests, any management member has a disinterested responsibility in the program, little success should be expected. Companies with long experience in supervisory development found that their activities soon outgrew the courses with which they first started.

We hear a great deal about canned programs. It is my opinion that many such programs have much valuable information in the packet but that unless the program is modified to fit the needs of the organization in question, it is nigh worthless. A program adopted for any organization must be attuned to the philosophy of management of that organization and also be attuned to the group to whom supervisory development is directed and to their work schedules. If top management is not thoroughly sold but is nonetheless urged by the desire to keep up with competition, there is little hope of success.

A course in human relations has been given in Sohio's production department each year for the last 3 years. The course uses Glover and Hower's "The Administrator" as its text and consists of about fifteen 2-hour sessions. Attendance is on a voluntary basis and classes meet once a week. The classes are made up of engineers, superintendents, accountants, auditors, purchasing agents, geologists, landmen,

and clerical supervisors. The class periods are devoted to discussion of cases taken from the text which are, of course, real situations in which only names and places have been disguised.

Here the class members, rather reluctantly at first, but with increased interest and enthusiasm, project themselves into the middle of the situation outlined in the text. In these discussions class members see problems in different ways. Soon they realize that even though all started with the same set of facts all did not make the same assumptions. Respect for the viewpoint of others became increasingly more apparent. Also, the serious effort to understand each other's viewpoints was easily observed. Some quite articulately observed that the case outlined in the text should have given more facts. In nearly every instance when that arose, some other class member would counter with a remark which was in essence that in any personnel problems all of the facts are not obtainable and that feelings, attitudes, emotions are facts which cannot be safely ignored in any problem involving people.

Thus far we have experienced little difficulty in creating and maintaining an atmosphere in which class members are apparently not inhibited from stating views nearest their heart. While I cannot give an objective evaluation of the course as given, since I have been the moderator, it is nonetheless true that personnel problems now get a much more thorough consideration than previously.

Conference method . . . Formal programs are conducted in many organizations by the conference method, and training in conference leadership is presently getting much attention. This method uses a specific topic for a conference period. I mention only a few topics in order to illustrate the nature of subjects:

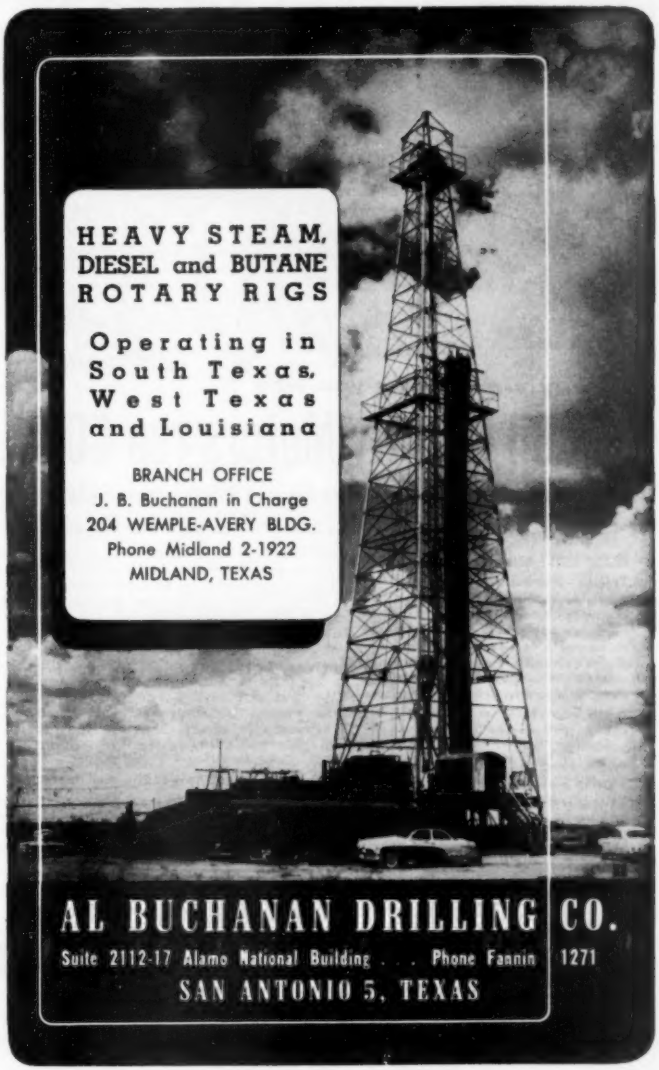
1. Induction and orientation of new employes.
2. Preventive discipline.
3. How to reprimand a worker.
4. Developing traits of leadership.
5. The supervisor as a teacher.
6. Getting along with other supervisors.

There is little doubt but that the conference method using specific topics is effective in the narrow limits of the subject discussed. Use of the case method as outlined above permits the supervisors to reflect on real situations and approaches the problem of satisfactory relationships between the supervisor and the individual worker in a broader context.

Many top people in industry bemoan the fact that adequate communications are difficult to establish and maintain within their organization. Here reference is not made to telegraph, telephone, teletype, interoffice communications, or company radio systems; rather what is meant is a system of communications which will in part transmit feelings, attitudes, and assumptions within the organization.

One major reason for the breakdown in communications between top management and the workers may have been the neglect with which the foremen in our business have been treated. These front-line supervisors are the link between management and the workers for communications going in either direction. Supervisory development may help to regain some of the ground lost in that the foremen could of themselves come to realize and understand that they are part of management rather than merely being so informed by top management.

Orders emanating from the top are more likely to be complied with if those affected by the orders from their own point of view understand the reasons behind the orders. Here is a difficult concept. A change in procedure may be most logical from the corporate point of view. Unless the reasons for the change are generally understood and accepted by those affected, the anticipated results from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the change will never be fully realized. This is much easier to accomplish if those affected are given the opportunity to express their views in a free and understanding atmosphere prior to the time the decision for the change is made. Supervisors at all levels should be encouraged to contribute within the limits of their own experience toward resolving any problem directly or indirectly affecting their work. That could be real participation rather than, as we sometimes observe in writings on this subject, being given a "sense" of participation.

There is a difference of opinion regarding who in an organization should conduct formal training in supervisory development. That is, should the formal sessions be conducted by line or staff personnel? My own conclusions are that so long as the line is squarely behind the program it is not absolutely essential that every session be conducted by a line supervisor. Staff people can and should supplement the program in fields in which their specialized training can be utilized. The planning and coordination of the program should be done by an industrial-relations or personnel-department group. This group should, after a time, be in a position to give top management evaluation of results based on more than personal opinions.

Increasing productivity . . . We have attempted to show that a supervisory-development program might help remove some of the obstacles which prevent people from doing their best. This could result in increasing productivity. Perhaps by repetition we have emphasized that the need for a program must be felt by and have the active support of the entire management group. The adopted program must be planned on a continuing basis and measurable or comparative results should not be expected too early. Programs must be planned for individual organizations in keeping with the existing climate in that organization.

Ultimate responsibility for personnel management rests with the operating supervisor and he is, therefore, the key individual in establishing and maintaining satisfactory relations with the work force. Who here has not at times felt that he could accomplish more if only the relations between him and his superior were better? The sense of accomplishment is deep seated in most people. If the relations between the workers and the front-line supervisors and between the various levels of management are improved, will that not only increase performance but also increase the opportunity for some measure of happiness for all in the organization?

During the past 2 years the A.P.I. Division of Production has been giving serious consideration to supervisory development. Committees in the several districts have been working earnestly in an effort to determine and outline the assistance that A.P.I. might give industry in this very important problem. Those connected with the Institute's committee work on supervisory development are concerned with gathering and compiling information on this subject to be made available to those companies and organizations requesting it.

We hope by papers at district meetings, by seminars and symposiums at either district or chapter level, to create more interest. Also, by the exchange of ideas at round-table discussions some companies may in their own programs avoid acknowledged mistakes made by others.

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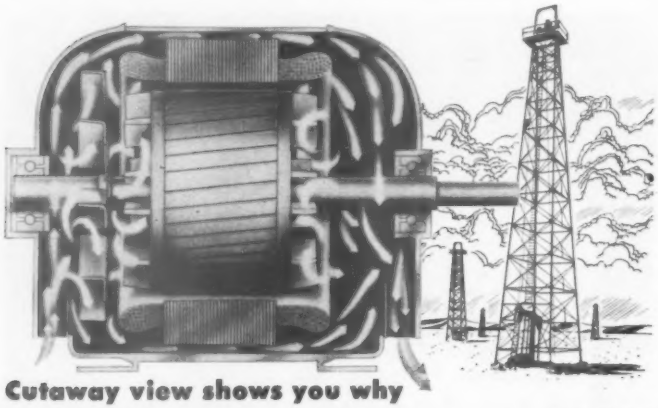

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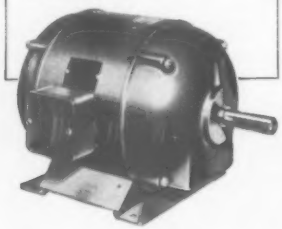

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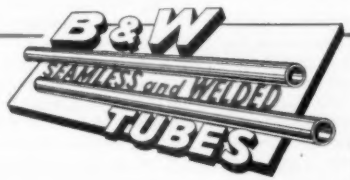

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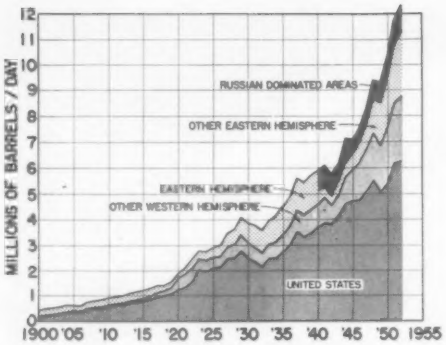
MILLIONS OF BARRELS / DAY
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OTHER EASTERN HEMISPHERE
EASTERN HEMISPHERE
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UNITED STATES
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Fig. 1—World crude-oil production.

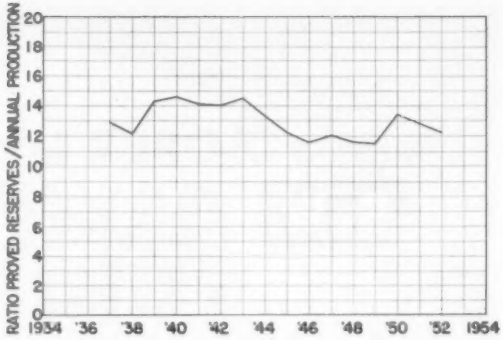


Fig. 2—Ratio of proved crude-oil reserves to annual production.

How the industry banks on

MEETING FUTURE PETROLEUM DEMANDS

Here two authors venture an analysis of the probable availability of crude oil and natural-gas liquids during the next 15 years. A demand forecast is attempted, and refinery capacity required is estimated. Transportation facilities are explored.

by John E. Swearingen* and John W. Boatwright†

PART 1
John E. Swearingen

WORLD crude-oil production now stands at a little over 12 million barrels per day, with the largest producers of the free world outside the United States being Venezuela and the countries of the Middle East. One fact is evident from Fig. 1. The growth in production of crude oil in the past decade has been much more rapid outside the continental United States than inside the borders of this country. Even a casual observation of Fig. 1 naturally raises the question: "How long can we continue to produce oil at an expanding rate without becoming dangerously dependent on foreign sources of supply?"

U. S. Crude-Oil Reserves

In trying to answer this question, the first thing to examine is the inventory of proved crude-oil reserves standing on the books. Figures on proved reserves prior to 1937 are not available on a consistent basis. During the past 15 years our country has more than doubled its proved reserves of crude oil, and this does not take into account an additional reserve of 4 billion barrels of natural-gas liquids which adds about 15 per cent more reserve supply. And this result has been accomplished while we were producing 24 billion barrels of crude oil. Only during the war years has the industry failed to add substantially to its crude-oil reserves. This is attributed principally to lack of steel pipe and skilled manpower during the war to carry on normal activities.

*General manager of production, and †general manager of distribution economics, Standard Oil Co. (Ind.). Presented at thirty-second annual A.P.I. meeting, Chicago.

Reserves vs. Production

Fig. 2 shows the ratio of reserves on January 1 of each year to the annual production in the preceding year. It will be noted that this ratio has varied from a low of about 11.5 in 1949 to a high of about 14.5 in 1940, and currently stands a little above 12. These are the figures which give rise to the claims of many uninformed persons that we are running out of oil; that our present supply will last only another 10, 12, or 14 years. In this connection, there are several things which should be pointed out.

In the first place, the reserve figures are proved reserves. Conservative figures on proved area, pay thickness, percentage recovery, etc., are used in making up the estimates. The "probable" or "possible" reserves of new areas may be many times larger than the "proved" reserves, but the proved reserves are the ones making up the A.P.I. figures. History has shown that A.P.I. proved reserves for fields in the year of discovery are generally only 15 to 25 per cent of the oil ultimately shown to be present.

In the second place, many wells now producing oil will continue to be producing 50 years or more from now. Even if it were desirable to produce all our oil reserves in a period such as 12 or 13 years, it would be physically impossible to do so.

Third, and most important, any such contention completely overlooks the fact that the industry is finding more oil every year than is being used, and there is every reason to believe that this situation will continue.

Proved Oil Developed vs. Annual Production

It is more logical to look at proved crude-oil reserves in the manner shown in Fig. 3. Here is plotted the ratio of proved crude oil developed each year to the then current rate of production. Fig. 3 shows that every year since 1937, with the exception of 1943, developed new oil is at least equal to production. Except for the war years, the industry has done much better than replace withdrawals. In fact, over the 15-year period for which data are available, 1.6 bbl. of oil has been developed to take the place of every barrel produced. This

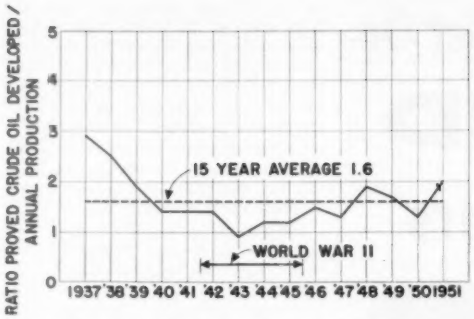

RATIO PROVED CRUDE OIL DEVELOPED / ANNUAL PRODUCTION
15 YEAR AVERAGE 1.6
WORLD WAR II
1937 38 39 40 41 42 43 44 45 46 47 48 49 50 1951

Fig. 3—Ratio of proved oil developed to annual production.

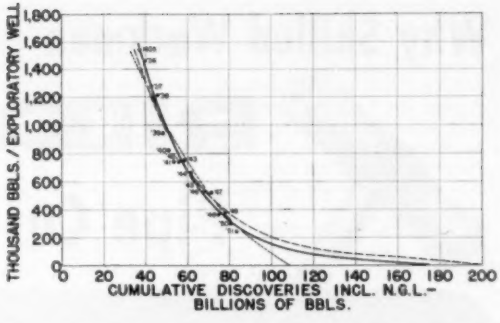


Fig. 4—Discoveries per exploratory well vs. cumulative discoveries.

record certainly does not bear out the contention that this country is running out of oil.

Reserve Growth and Drilling Activity

Basically, in order to develop new crude-oil reserves, wildcat and development wells must be drilled. In years when money and pipe were available, new reserves added were high. During the war years of restricted steel availability, new reserves discovered were appreciably lower.

Fig. 4 shows the relation between oil discovered by exploratory drilling and the cumulative amount of oil which has been discovered. Fig. 4 is based on data published every year by H. J. Struth, who takes the new reserves added each year and credits them back to the year of the field's initial discovery; it is also based on the records of exploratory drilling published each year by F. H. Lahee. One of the serious difficulties of this procedure is that it gives an unreliable picture of recent discoveries, for the reason that sufficient time has not elapsed to prove up the ultimate reserves attributable to new fields.

Adjustment of data . . . Analysis of Struth's data indicates that, after about 8 years, revisions and extensions add almost nothing to the proved reserves of a given reservoir. On the other hand, experience has shown that ultimate reserves of a given field average from four to six times the reserve assigned to it in the year of discovery. To recognize this situation, Struth's data have been adjusted.

In 1935 and 1936, Fig. 4 shows that the average exploratory well discovered about 1,500,000 bbl. of oil, whereas in 1951 the average exploratory well discovered less than 250,000 bbl. of oil. Extrapolation of this curve, in an effort to determine the ultimate amount of oil to be produced in the United States, can easily give any figure between 110 and 200 million barrels. Of course, if Fig. 4 were large enough, the extrapolation curve could be extended beyond 200 million barrels.

Fig. 4 is a very interesting chart, and one dear to the hearts of exponents of the philosophy that we are running out of oil. Basically, it is their argument that oil is becoming harder and harder to find and, even allowing for new discoveries, the available prospects for new oil production will soon be exhausted.

Unsound conclusion . . . But this conclusion is believed to be unsound. In the first place it is impossible in the year of discovery of any new field to estimate its ultimate production accurately. Even though an attempt is made to correct the basic data to allow for this situation, the correction factors are so large (from four to six times the size of the figures actually reported) that no reliance can truly be placed on the result. And, when these extrapolations of actual data are extrapolated themselves, the results are not dependable.

In the second place, the drill is beginning to be used more and more extensively as an exploration tool. Drilling costs have gone up sharply in the past decade, but so have the costs of seismographing and other geophysical operations.

In some areas where geophysical methods are unreliable, such as parts of the Edwards plateau country of West Texas, the drill is the only exploration technique which can be employed effectly. There seems to be no doubt that the future will see increasing use of wildcat wells as an exploration tool—particularly if the industry is able to devise means of reducing drilling costs.

Untapped areas . . . On top of this, Fig. 4 appears to show only the trend in discoveries in oil provinces where the

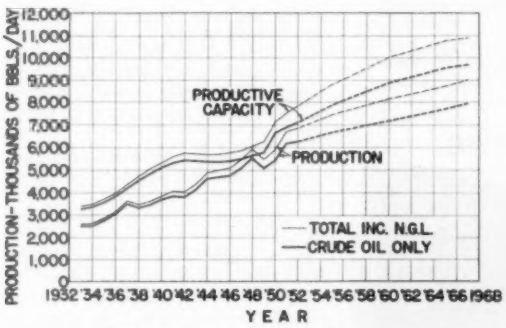

PRODUCTION—THOUSANDS OF BBLS./DAY
PRODUCTIVE CAPACITY
PRODUCTION
TOTAL INC. N.G.L.
CRUDE OIL ONLY
1932 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66 1968
YEAR

Fig. 5—United States productive capacity and production.

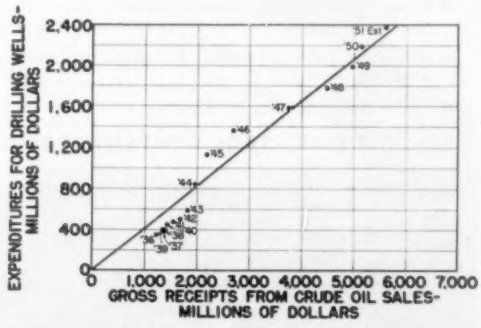
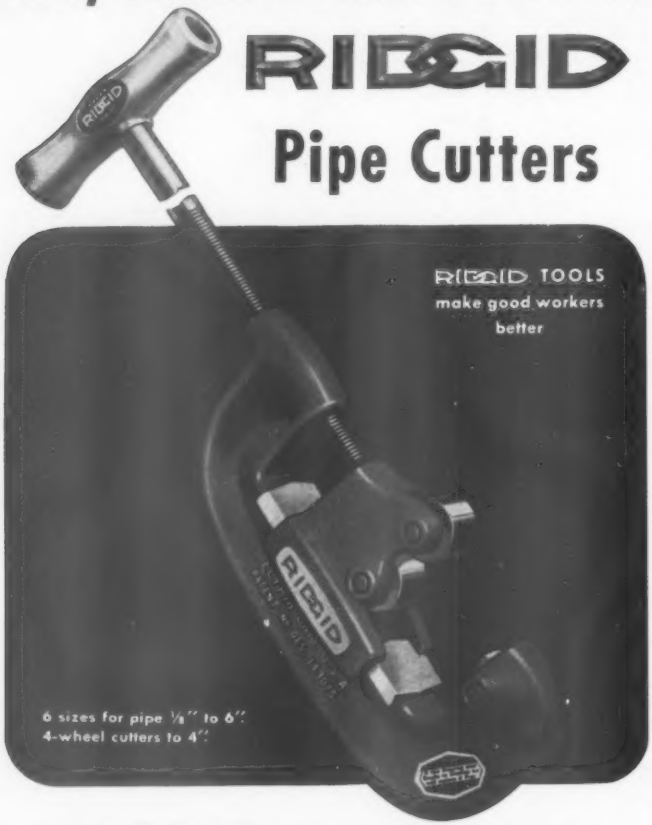


Fig. 6—Gross receipts from crude-oil sales vs. expenditures for drilling wells (3-year average).

Why Skilled Workmen Insist On RIDGID Pipe Cutters



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industry is now operating. There are large areas of the United States which have never been tapped by the drill, such as the Great basin of Nevada, much of Arizona and western New Mexico, and large areas in the northern Rocky Mountains, to name but a few. The tidelands are relatively undeveloped, and only 2 years ago one could still say that there was no oil in the 60-million-acre Williston basin.

Even in the known oil country, there are some large and favorable areas which have not been adequately explored and drilled. The best of these are large ranches in the lower Gulf Coast and in West Texas. Where enormous ranches are owned in rich oil territory, present high income-tax rates tend to prevent exploration and postpone possible production to future years. If the landowner's income is so large that he pays most of it to the Government in taxes, he is not interested in additional development which will increase income. Some day all of those areas will be drilled.

Basis for This Forecast

In developing this forecast, oil-finding people who work in all of the major producing provinces of the United States have been consulted, and this forecast represents the consensus of their views. Estimates of future production potentials of the various areas have been crosschecked with one another, and have been revised and adjusted to what is believed to be a mutually consistent basis and one not in conflict with such statistical evidence as can be employed.

For purposes of this study, each of several groups of exploration people was asked to prepare its forecasts on the assumption that a market would be available for all of the crude oil which could be produced at maximum efficient rate of production. With MER production rates as estimated, the number of future discoveries and wells necessary to produce at these rates can be derived. After preparation of these estimates, and after the demand rates discussed in the second part of this paper had been taken into account, it became evident that more oil would probably be available than could be consumed if the fields should be produced at MER rates.

By a successive approximation procedure, it was then possible to estimate reserve producing capacity on a basis consistent with expected rates of production.

As a result of all of these adjustments, this forecast shows a substantial increase in reserve producing capacity over the next 15 years. If we continue in a warlike economy for the next several years, it may be desirable to pro-

vide this reserve-producing capacity. If, on the other hand, conditions change so that this extra capacity is not needed, the exploration and drilling programs of the industry will probably be curtailed and will thus postpone the finding and development of some of the producing capacity forecast in this study.

Geologists optimistic . . . In considering these predictions, it should be kept in mind that geologists in the United States and Canada have been very successful in finding new oil fields during the past 2 or 3 years and are, therefore, optimistic about their continued ability to find oil.

Had the present forecast been made 4 or 5 years ago, it might not have been so optimistic, and it is possible that a similar forecast 5 years from now might be more pessimistic. But, notwithstanding this inherent question of accuracy, the oil finders' appraisal of their future hunting ground is better than any outsider could possibly make.

The present forecast of supplies includes a considerable amount of oil attributed to secondary recovery by water-drive and gas-drive methods, but assumes no drastic change in these practices. The forecast contains no production which may ultimately be developed as a result of new secondary-recovery methods not yet perfected in the field practice.

Production and Availability

Our forecast of production of crude oil and natural-gas liquids in the United States for the next 15 years is shown in Fig. 5. This chart shows not only our forecast of production of crude oil and natural-gas liquids through 1967, but also our estimate of the nation's productive capacity. Several things are noteworthy about Fig. 5. First, it is believed that domestic production of crude oil will continue to increase over the period we have considered and, second, that the industry will be building up its producing capacity faster than production.

Our estimate shows that the industry in 1967 will be producing about 8 million barrels per day of crude and 1,100,000 bbl. per day of natural-gas liquids—a total of about 9,100,000 bbl. per day. This is an increase of about 2,200,000 bbl. per day over present levels, or about 33 per cent. Natural-gas liquids are expected to become an increasingly important part of the supply picture as gas sales increase and pressure-maintenance projects come into more general use for increasing ultimate crude-oil recovery.

Industry's capacity taxed . . . It will be noted that the nation's productive capacity has appreciably exceeded actual production except during the years immediately following the war, when release of the pent-up demand severely taxed the industry's capacity. At present there is reserve producing capacity of about 900,000 bbl. per day. Our forecast expects this reserve capacity to increase to about 1,900,000 bbl. per day in 1967, or about 21 per cent of the daily rate of production at that time.

In summary of Fig. 5, it is our conclusion that the domestic oil industry will find enough oil in the next 15 years to meet foreseeable demand and, barring a major war with virtually complete cessation of imports, the industry will have a comfortable margin of producing capacity in excess of actual requirements.

To reach a producing capacity of the magnitude shown in Fig. 5, the oil industry of the United States must find and develop approximately 49 billion barrels of crude oil between January 1, 1952, and the end of 1967. This task should be measured by the industry's production, from its beginning to date, of approximately 42 billion barrels and total discoveries to date (production plus reserves) of about 71 billion barrels.

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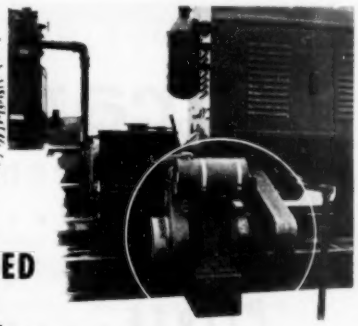

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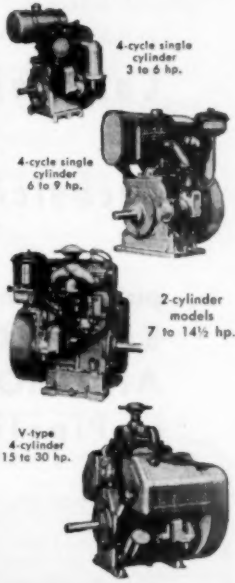

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indicates that, by the end of 1967, cumulative crude-oil discoveries should reach 120 billion barrels, with proved reserves standing at 38 billion barrels —about 13 times the then current rate of production. If this task seems large, it is pointed out that during the past 15 years the industry has added 39 billion barrels as compared with 49 billion barrels for the next 15 years. The oil industry is a growing one; it is producing more oil, drilling more wells, and doing more exploration, than ever before. Today almost 700 seismograph crews, as compared with only 200 in 1937, are operating. More geologists are looking for oil than ever before. Although figures on employment of geologists by the industry are not available, an indirect measurement is afforded by membership in the American Association of Petroleum Geologists. A.A.P.G. membership has increased from 2,300 to 9,300 in the past 15 years—a fourfold increase. And it should be noticed that all of these yardsticks do not take into consideration the improvement in quality of effort.

Significant developments . . . Although our forecast shows a sizable increase in exploratory drilling, the number of field-development wells required will be not appreciably larger than at present. The total number of wells forecated for 1967, viz., 62,000, appears to be easily within the reach of the industry. Interesting, of course, will be the source of all this oil of the future. The following discussion outlines briefly the significant developments expected in future years.

In PAD District 1 the only states now producing oil are New York, Pennsylvania, West Virginia, and Florida. Our forecasting shows that this area will increase in production from about 69,000 bbl. per day in 1951 to about 115,000 bbl. per day in 1967. The major part of this new oil is expected to come from Florida, and the old producing areas of New York, Pennsylvania, and West Virginia are expected to continue their gradual decline.

Our estimating reveals that production in PAD District 2 will increase from 1,176,000 bbl. per day in 1951 to about 1,490,000 bbl. per day in 1967. The major portion of this increase should come from North Dakota, and South Dakota for which states production is forecast at a rate of about 316,000 bbl. per day in 1967. At present there are two large-sized pools under development in North Dakota. Oil has been found in several different producing horizons in these pools, and 17 rigs are now actively drilling. Little change is expected in production in other states of District 2.

Production in District 3 is estimated to increase from 4,119,000 bbl. per day in 1951 to 5,720,000 bbl. per day in 1967. Louisiana alone is expected to increase from about 697,000 bbl. per day to about 1,180,000 bbl. per day, with about 290,000 bbl. per day coming from offshore properties, as compared with about 19,000 bbl. per day last year. Mississippi production is expected to double from 105,000 bbl. per day to about 209,000 bbl. per day. Texas offshore fields are expected to be producing some 68,000 bbl. per day 15 years from now. Substantial increases are anticipated in production along the Texas Gulf Coast — from about 1,050,000 bbl. per day to 1,530,000 bbl. per day—and almost as much from the prolific Permain basin of West Texas.

District 4 is forecast as increasing in production from 297,000 bbl. per day in 1951 to 619,000 bbl. per day in 1967. The Montana portion of the Williston basin is expected to grow to about 180,000 bbl. per day in the next 15 years, and Wyoming's production to expand a little more than 100,000 bbl. per day. Several important pools have already been found in eastern Montana, and a number of others are sure to be found in due course.

In District 5, the present rate of pro-

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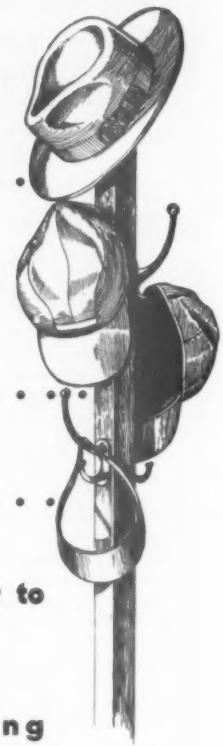

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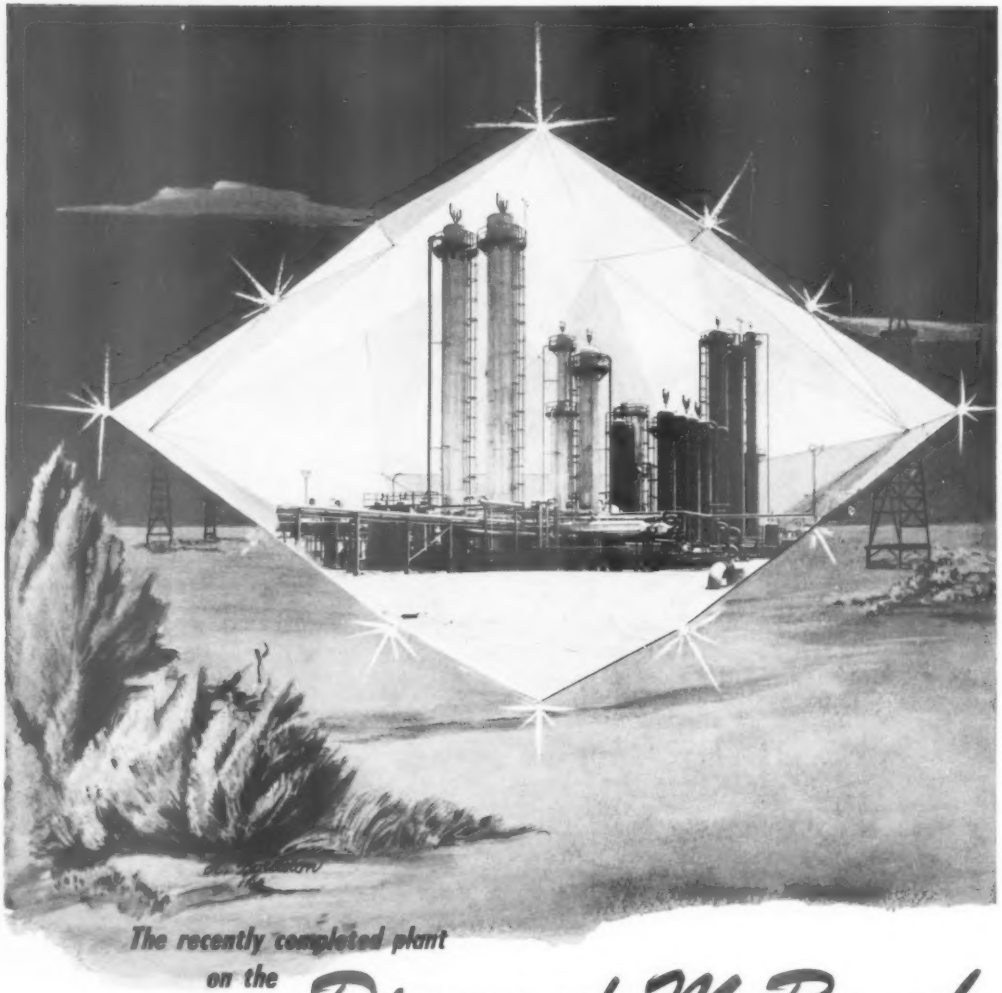

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duction of 1,052,000 bbl. is expected to be maintained at essentially present levels throughout the forecast period. Production onshore in California will probably decline, but this should be offset by development of the California tidelands. Our figures do not include any production from the Elk Hills Naval Reserve, which is a major reservoir, but which probably will not be produced unless our country goes into an all-out war.

No detailed forecast is made here of the quality of crude oil which will be available in future years, though there is some basis for belief that a higher proportion of low-sulfur crude will be avaialble than has been the case in the recent past. Crude oil from the Williston basin, from the offshore areas of Texas and Louisiana, and from the deep pays of the Permian basin, by and large is low in sulfur content. These are areas which should produce most of the additional oil which will be needed over the next 15 years.

Natural-Gas-Liquids Availability

The preceding discussion has been concerned principally with availability of crude oil, but recent years have seen a dramatic increase in recovery of liquids from natural gas. Gasoline-plant capacity in the country has expanded enormously in recent years. More natural-gas-liquids extraction plants are expected to be installed along the large interstate gas pipe lines to remove propane, butane, and heavier materials from gas streams intended for industrial or residential consumption. The industry's development of salt-cavity storage will provide badly needed facilities for storing L.P.G. during slack demand periods for later recovery and marketing during periods of high demand.

Refining changes . . . Production of natural-gas liquids will rise from 564,000 in 1951 to about 1,065,000 bbl. per day in 1967, according to our forecast. The larger proportion of volatile liquids available may necessitate some changes in refining operations, but growth will be gradual, and adjustments to use of this raw material will be made over a period of time.

Other Prospects for Additional Oil

Present methods of oil production, on the average, recover 25 to 35 per cent of the oil in place in the ground. In fields where a natural water drive is present, such as East Texas, recoveries may ultimately be as high as 80 per cent of the oil originally in place. In pools where a natural water drive is not present but where water injection can be practiced, recoveries can frequently be increased from 25 to 35 per cent to the range of 40 to 60 per cent of the oil in place.

If technologists of the industry can devise means of substantially improving present recovery practices, many billions of barrels can be added to known reserves at no finding cost, and can push even further into the future the day when this country will be deficient in its oil supplies. This problem is being studied, and some of the ideas now in the laboratory or yet to be discovered may prove practical for field application.

The figures of our forecast assume a normal increase in water flooding, gas injection, and other conventional methods of secondary recovery, but they do not recognize the possibility of any increased production through application of techniques not now in commercial use.

New basins . . . There is a much larger area of this country which is potential oil territory than appears in the producing column today. Naturally, the oil industry has explored for oil fields in those territories which appear to have the best production prospects. But it should be pointed out that the large areas of the Williston basin of the Dakotas and Montana, and the Uinta basin of Utah and Colorado, had no oil production 5 years ago. They are now being actively explored and de-

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veloped, and their producing areas will be enlarged still more.

Any day one of these other prospective areas, such as the Great basin in Nevada and Utah, southeastern Colorado, the Salina basin in Kansas and Nebraska, or any of several others, could break into the producing column. Improved techniques of seismograph and other geophysical methods, together with improvements in drilling practices, which would lower the cost of digging wells, could do much to extend the present producing area and productive capacity of this country.

This paper is primarily concerned with the availability of oil from domestic production for the refineries of the United States, but any such discussion would not be complete without some comment on the foreign oil situation. At present reserves of oil and natural-gas liquids in the United States stand at some 32 billion barrels, as compared with some 74 billion barrels for the rest of the free world; 52 billion barrels of these reserves are located in the Middle East; most of the remainder is located in Venezuela and other South American countries.

At present the United States is importing a little more than 900,000 bbl. per day of crude oil and refined products. If production capacity of this country increases at the rates set out in this forecast, we expect to see a gradual increase in imports to about 1,420,000 bbl. per day in 1967. By and large, our expectations are that most of the foreign crude brought into this country will be processed in refineries along the East Coast. Although Canadian crude-oil production is expected to increase from about 132,000 bbl. per day in 1951 to 715,000 bbl. per day in 1967, anticipations are that imports of Canadian crude will be primarily for use in the Pacific Northwest and the area around the head of the Great Lakes.

Our estimates of foreign crude-oil production capacity indicate that there will be substantially more crude available than will probably be permitted to enter this country. As is well known, importation of crude oil is a matter subject to governmental regulation, and governmental regulation is a field in which forecasting is more of a guess than a science.

Conclusion

In considering the future supply of oil for the United States, one other chart, Fig. 6, should be discussed. Here is shown a comparison between gross income received from crude-oil sales and total expenditures for drilling oil wells. To obtain the gross income, the nation's annual production of crude oil is multiplied by the average price per barrel. This gives a measure of the gross cash supply of the producing industry and, of course, disregards income from gas sales and other incidental operations, borrowings, and the fact that payments to royalty owners frequently are not reinvested in the business. Obtaining figures on well costs of the industry was somewhat of a handicap, because complete records are not available. It is easy to obtain the total number of wells and the average depth drilled, but it is practically impossible to obtain an average cost per foot drilled because of the wide variations between areas and the fact that drilling costs increase at least geometrically with depth.

For purposes of Fig. 6, some figures published last year by H. J. Struth which show the total cost of all wildcats and development dry holes were used. These figures are assumed to be a representative sample of all wells drilled. This assumption is subject to some criticism, but deficiencies in the figures are not believed to be material. The relationship shown was checked with several independent sources of in-

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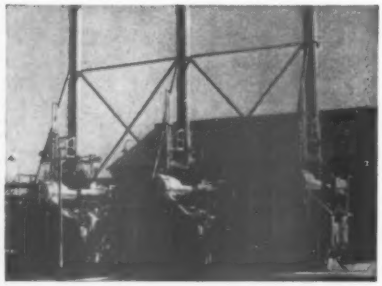

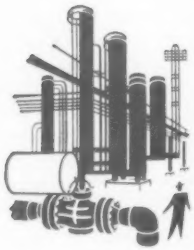

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formation, and the basic relationship depicted is thought to be correct.

Division of expenditures . . . It will be noted that Fig. 6 shows a direct correlation between money available to the oil industry and the money spent for drilling wells. The line in Fig. 6 indicates that the industry spends a little more than 40 per cent of its gross income for drilling. Although no precise figures are available, a roughly equivalent amount goes into exploration and leasing, and the balance goes into taxes, overhead, profit, and general expenses. The correlation is excellent, except during the years 1944, 1945, and 1946, when the industry continued to spend more than normal amounts of money for wells even though the price of crude oil was frozen at an unduly low level.

Now, as to the significance of Fig. 6, it indicates that drilling activity is related directly to industry income. If the oil-producing industry is to achieve the levels of production predicted in this forecast, it must have the money to do the exploration and development. If the Government takes a bigger tax bite; if the depletion allowance is reduced or done away with; or if arbitrary and costly regulations are imposed to restrict freedom of activity, each will have a direct bearing on the industry's ability to find new oil. If the price of crude oil is fixed while drilling costs are permitted to rise, the total number of wells which can be drilled must necessarily be reduced. At this point it should be emphasized that drilling costs, because of inflation, increasing depth, etc., have increased almost fivefold during the past 15 years; that they have increased substantially since the war; and that crude-oil prices have remained unchanged since 1947.

In conclusion, it is the author's firm conviction that the domestic oil industry can supply sufficient oil to meet all of our needs for the foreseeable future; but, no matter whether the industry can do these things, the result will not be achieved unless the industry is permitted the freedom to do the job which has to be done.

PART 2

John W. Boatwright

Introduction

IN prepartion of Part I of this paper Mr. Swearingen and his associates reviewed the possible future productive capacity irrespective of what the demand may be. I started at the other extreme, and estimated what the demand might be irrespective of problems of availability. These estimates of demand were then made available to Mr. Swearingen so that he could determine the probable future production rates. Reflecting these probable future production rates, he was able to build his estimate of future availability by years — recognizing a normal or expected production rate.

A comparison of probable availability with the future consumption level indicates that supplies are adequate to meet total requirements. This comparison also reveals the probability of surplus supplies, the extent of the margin of safety, and whether synthetic-fuel production is likely to be required during this time period.

The forecast of the extent of the market and the study of future probable supplies were not sufficient to answer all of the challenges which required consideration. If the petroleum industry is to achieve the full satisfaction of petroleum needs, adequate facilities must be available for moving crude oil to the refineries and finished products to the market. Refinery capacity must be adequate to process total needs, with a proper margin for security purposes. These additional considerations are also covered in this analysis.

Authors of papers such as these should either present the assumptions underlying their work, or they should indicate that the work is based upon the broad assumption that present economic controls will be eliminated and that an industry free to make decisions on economic considerations will be reestablished. We have followed the latter course. But there are, and will be, many economic problems which—depending upon the manner in which they are met—could greatly modify anticipated achievements. These will be touched upon briefly.

Anticipated Demand

This forecast of petroleum demand has been made giving recognition to the nation's total output of goods and services. No attempt was made to time a business recession or recessions, although this possibility was clearly recognized. In reviewing a 15-year time period, the basic growth factors of the economy are believed to be more significant than annual deviations which may occur about that growth curve.

The anticipated growth of population, the expansion of industrial production, capital investment in new plants and durable equipment, the employment level, and other underlying basic economic trends were studied. Individual uses of petroleum were analyzed against that background.

Total energy needs and the shifting proportion of the total supplied by petroleum, transportation requirements represented by number of units and consumption per unit, radiation units installed and requirements per annum, and industrial processing with petroleum products were analyzed from historical data and probable future needs.

Off-highway needs . . . Agricultural and other off-the-highway needs for gasoline and other petroleum products were studied. All in all, several hundred indexes of change were analyzed to the best of our ability in order to ascertain the probable future needs for petroleum products.

Let us refer only to the more salient features of this forecast (Table 1):

1. Total demand for petroleum products is forecast to increase from 7,043,000 to 10,280,000 bbl. daily by 1967, or a 46 per cent plus gain. Exports should decline as a result of increased refinery capacity built in foreign lands. Reflecting the influence of this decline in exports, total demand for all products should increase from 7,466,000 bbl. to 10,400,000 bbl. daily, or an increase of 39 per cent.

2. The forecast of domestic demand for gasoline, representing a 46 per cent expansion, reflects our guess of growing military needs, as well as the increased requirements for civilian uses. Incidentally, the growth in gasoline requirements would have been higher had it not been for the competition we anticipate from the use of liquefied petroleum gas by trucks, tractors, buses, etc.

3. The increase of 44 per cent for kerosine and distillates reflects the

TABLE 1—U. S. TOTAL DEMAND
(Figures in thousands of barrels per day)

Domestic—	1951	1955	1960	1965	1967	Per cent increase 1967 over 1951
Gasoline	2,987	3,545	3,910	4,230	4,350	46
Kerosine and distillate fuel	1,569	1,869	2,064	2,210	2,260	44
Residual fuel	1,544	1,648	1,716	1,823	1,860	20
Other products	943	1,238	1,490	1,727	1,810	92
Total domestic demand, all products	7,043	8,300	9,180	9,990	10,280	46
Total exports	423	165	125	120	120	—72
Total demand, all products	7,466	8,465	9,305	10,110	10,400	39

TABLE 2 — DOMESTIC AVAILABILITY VS. TOTAL DEMAND
(Figures in thousands of barrels per day)

Year	Domestic availability of crude oil and nat.-gas liquids	Total demand incl. exports	Margin of domestic supply over total demand
1950	7,123	6,812	311
1951	7,537	7,467	70
1955	8,792	8,465	327
1960	10,016	9,305	711
1965	10,736	10,110	626
1967	10,902	10,400	502

growth of jet-fuel utilization, the continued trend to dieselization, and the growth of present and new uses for the product.

4. The forecast of demand for residual fuel represents the smallest increase of any of the product classifications. Utilization of this product, by types of industries, presents contrasting trends—some increasing and some declining. Probably the most significant industry trend recognized was that oil-fired steam locomotives would be almost entirely converted to diesel fuel considerably prior to 1967.

5. The most significant increase forecast applies to "other products," including lubricating oils, asphalts, waxes, petroleum chemicals, coke, still gas, and liquefied petroleum gas. The sizable increase in volume of liquefied gas, representing a gain of 175 per cent, explains the major portion of growth anticipated for this class of products.

The Adequacy of Supplies

A comparison of demand with estimated supplies of crude oil and natural-gas liquids is offered on two bases so that conclusions may be drawn which reflect the degree of conservatism of the individual reader.

It will be noted from the comparison in Table 2 that purely domestic supplies will be adequate to meet total needs without imports, and will still afford the nation a protective cushion of about 5 per cent. But this comparison is unrealistic to the extent that there will be imports of both crude and products. A comparison on this basis is given in Table 3.

TABLE 3 — TOTAL AVAILABILITY VS. TOTAL DEMAND
(Figures in thousands of barrels per day)

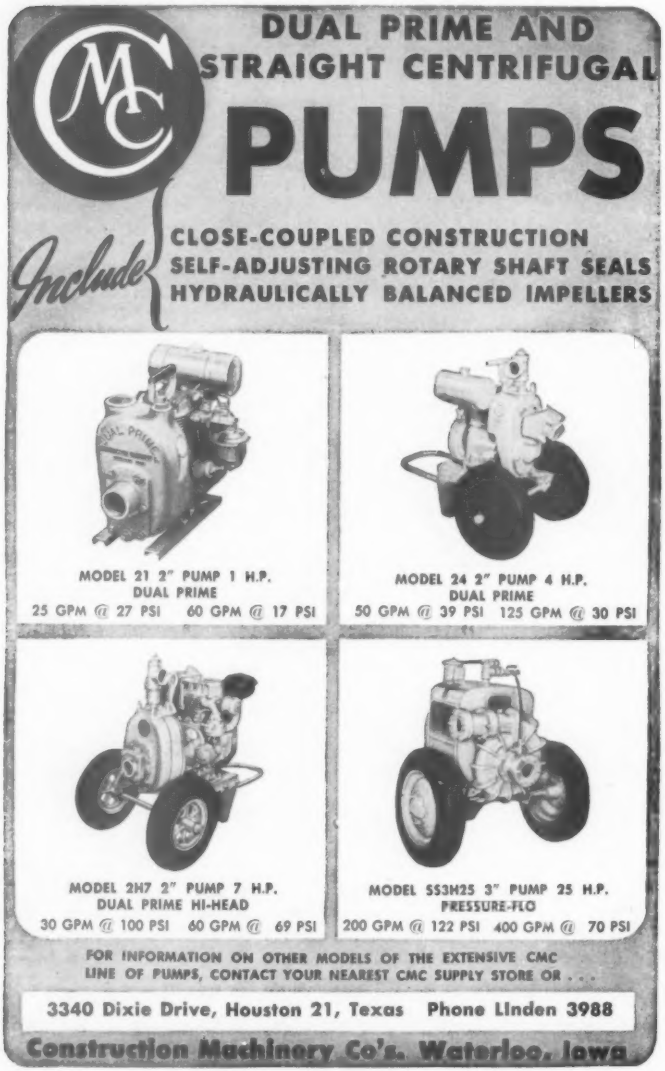
Year	Total estimated supplies*	Total demand†	Estimated margin‡
1950	7,610	6,449	1,161
1951	8,028	7,114	914
1955	9,492	8,123	1,369
1960	10,830	8,928	1,902
1965	11,652	9,637	2,015
1967	11,837	9,918	1,919

*Of crude oil and natural-gas liquids from domestic production plus imports. †Including exports minus imports of finished products. ‡Of total supply over total demand.

It will be noted that the protective cushion ranges up to 2 million barrels daily, amounting to between 18 and 20 per cent over requirements. The Petroleum Administration for Defense is now advocating for security reasons that reserve producing capacity be pushed to about 25 per cent above total domestic demand, including imports. It is believed that this level cannot be achieved without some major adjustments to the industry's drilling program. In fact, it is doubtful that the industry will be able to carry a margin of greater than approximately 20 per cent over current demand.

Synthetic fallacy . . . There has been considerable study of production of synthetic fuels to supplement the availability of crude oil. Repeated study and analysis of this problem are healthy. To advocate building a synthetic industry, however, is to select the synthetic route as preferable to the traditional means of increasing supplies. This is a decision which should be based on economic considerations.*

It is not wished to enter into, nor to discuss differences in, reports by committees, consultants, or the Bureau of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Mines on this subject. But isn't the answer relatively clear? Men in petroleum are well acquainted with synthetic-fuel production processes. Petroleum capital will build such plants as soon as the conviction has been reached that production of synthetic fuels affords a more attractive return on investment than alternate use of that capital in customary development. Thus economic considerations will determine when synthetic plants will, and should, be built.

When may such economic conditions indicate that synthetic-plant production may be anticipated? No one knows. In terms of total supply, there appears to be a healthy cushion of sufficient magnitude for the next 15 years so that any construction as of this date would be at tremendous social cost. Also, it should not be forgotten that our estimates of future availability of crude oil and natural-gas liquids reflect economic pressures for increased supplies.

If the Government builds plants for producing synthetic fuels from shale, coal, or gas and thus competes with industry, this tends to reduce the private search for oil supplies from natural sources. If such plants are operated in competition with private industry and do not make money, then the total availability of oil is less than it would have been if the same amount of money had been spent for direct exploration. If these plants are not operated because they cannot operate at a profit, wastes are compounded to ridiculous amounts. And, to repeat, if they can be operated at a profit comparable with that earned from other sources of oil, oil men will build them.

Probable Crude Runs and Refinery Capacity

Total requirements of petroleum products will be supplied from several different sources. Imports of finished products, particularly heavy fuels, will continue to supply an important part of demand. Transfers from crude and natural-gas liquids will also supply an important segment of the total. After making these and other minor adjustments — such as losses, crude exports, and refined-product inventory changes—the probable crude runs by years will be as indicated in Table 4.

Assume that the ratio of crude runs to total capacity in 1967 will be approximately the levels maintained during recent years. This gives a clue to the probable refining capacity of the industry. On this basis, total refinery capacity in the nation will be approximately 10,700,000 bbl. This will require an annual expansion of total refinery capacity of approximately 250,000 bbl. Certainly this presents no unusual challenge to the industry in the light of what it has achieved since 1946—average building rate per annum from 1946 through 1951 having been 320,000 bbl. per day. And, when total refinery building is thought of, it must be recognized that the industry will have to replace obsolete equipment as well as add new capacity. Estimated expenditures by refineries alone in 1952 will probably exceed 1 billion dollars. There is no question that the industry will provide adequate refining capacity to meet market needs.

TABLE 4—ESTIMATED CRUDE RUNS REQUIRED

(Figures in thousands of barrels per day)

1950	5,739
1951	6,494
1955	7,253
1960	7,878
1965	8,503
1967	8,763

Refinery locations . . . In connection with constructing new refineries, some interesting new developments will unquestionably be evidenced. Factors determining the economics of refinery location are changing. Technological progress of fuel reduction is resulting in higher yields of light products susceptible to pipe-line movement and in

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lower yields of residual fuels not susceptible to low-cost transport movement. This changed pattern of yields, and the ICC limitation on earnings on crude-oil pipe-line investment to 8 per cent and the permissible rate of earnings of 10 per cent on product pipe lines, are important factors in determining the location of a new refinery.

Inasmuch as new crude-producing areas must be connected to future markets, there are sound reasons for anticipating a greater dispersal of refineries—and this offers the advantage of decentralization of military targets, a greater dependence upon product pipe lines, and a reduced relative dependence upon crude-oil pipe lines.

Transportation Requirements

Increased quantities of crude oil and natural-gas liquids must be brought to the refinery, and the finished products must be moved from the refinery to the market. This means that transportation facilities will be expanded. Crude-oil pipe lines will be built from new sources of crude to present refinery centers, and to new refinery centers; whereas new product pipe lines will be built from new refinery centers into markets which are presently served by pipe lines, and into markets which are not today considered sufficiently concentrated to warrant expenditures for such facilities.

The details of probable future pipeline construction from individual points of origin to individual destinations cannot be gone into. Nor can the economic pressures which may come into existence be forecast with sufficient accuracy at this time to merit individual-project conclusions. This problem, therefore, has been approached purely on a statistical basis. It would appear that crude-oil and products trunk-line traffic will increase by some 400 billion barrel-miles. This means that, between now and 1967, the industry will build a net increase to its present pipeline system equal to approximately half of present carrying capacity.

Another substantial consideration which needs to be recognized in the transportation factor is that the carrying capacity of ocean tankers will have to be increased. Adjustments of the carrying capacity of barges, tank cars, and truck transports will be made on a regular annual basis as may be needed by the market.

Basic conclusions . . . Thus our review of the probable 15-year future leads us to certain basic conclusions.

1. We feel confident that the future supply of crude oil and natural-gas liquids will be adequate to meet the needs of a greatly expanded market. Nevertheless, it is also felt that the demand for a larger backlog of producing capacity will result in greater and greater exploratory effort.

2. Even though many have considered that the postwar refinery building programs were of a catching-up nature, it now appears that building at almost the average rate achieved since 1946 will be normal expectancy for the future.

3. Adjustments, changes, and constant expansion of transportation facilities will be needed in the future.

This analysis gives confidence that the industry should be able to continue to do the job which it has always achieved, viz., supplying all the oil needed. "Growth" is perhaps the one word which best characterizes the future of the petroleum industry.

A Few Major Economic Considerations

In the conduct of this study many economic uncertainties which had to be resolved by assumptions were encountered. The validity of the forecasts depends upon the accuracy of judgment. It is believed that these problems and conclusions regarding them are of interest. If subsequent events prove to be different from what has been con-

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cluded, then the prognostications would have to be changed.

Monetary Stability

A greater degree of monetary stability than has been in evidence in the past 5 years has been assumed here. This is an essential requirement to the accomplishment of the objectives previously discussed. It is not desired to discuss the effects of inflation or deflation on future industry growth. However, attention should be called to the fact that industry is now in that phase of economic evolution where confiscation of property is reaching into investment in capital tools. Perhaps the situation can best be stated:

1. Depreciation allowances for profit determination for income-tax purposes are inadequate to replace capital tools now in use.
2. The understatement of depreciation results automatically in a corresponding overstatement of reported earnings.
3. Reported earnings are subject to graduated income-tax payments. An income tax is actually paid every year on a part of the capital invested in fixed plant facilities. Therefore, industry is in a period of capital-tools confiscation. Obviously expansion cannot be built soundly upon such a foundation.

If this industry and other industries in this country are to achieve the growth needed to meet the requirements of a greater population and defense objectives, it will be necessary that a certain stability of the purchasing power of the dollar be achieved.

Financial requirements . . . Most people look at an industry facing a substantial market expansion with considerable optimism. This is as it should be, but there is a problem which must be recognized. We in petroleum realize that frequently our expansion capital must be expended from 2 to probably 6 years ahead of the period of actual need. That is why there is truth in a tendency recently expressed by a friend of mine—that the greater our sales, the poorer will be our cash position. Petroleum is a heavy capital-requirement industry. Its cash is frequently drained off to provide expansion required in the future.

Very few people, either in or outside the industry, realize the magnitude of capital requirements which will have to be met to build for a future market of the size discussed. No one knows what the actual total investment will be. The best anyone can do is to approximate. Our approximations resulted in a staggering concept of future capital requirements. We believe that total future expenditures for exploration and development of necessary reserves, for transportation facilities, and for refining and distribution needs will average approximately 5 billion dollars per year. In fact, we are looking at a 75-billion-dollar program. This estimate is based upon the 1952 purchasing power of the dollar. If inflation continues, the amount will be correspondingly increased.

We have assumed that the industry would finance this growth, but it cannot be financed from reserves and retained earnings. However, we believe it well for all members of the industry to recognize that financing industry expansion is one of our greatest future responsibilities. We feel that it is even more vital that people outside the industry appreciate the essentiality of the profit incentive, as well as the inescapable necessity of plowing back a part of earnings, if we are to continue to grow.

Price freedom . . . What assumption should be made about future price regulations? It is recognized that most of the historical pattern had been established when the economy was not sub-

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ject to governmental price ceilings. It is also known that prolonged price regulation leads to rigidities of an economy, and these inevitably retard growth. Hence it is assumed that present price regulations as applicable to petroleum would not prevail for much of the 15 years under review.

This appears to be a logical assumption, because:

1. Supplies are considerably in excess of present rate of consumption.
2. Supplies are susceptible to substantial expansion both from domestic and foreign sources.
3. The geographical distribution of supplies and the production rate of particular products are often adversely affected by insensitive price ceilings.
4. Price ceilings do not recognize growth requirements.
5. A vast proportion of petroleum is now being sold at less than ceiling prices.
6. The potentiality of increased foreign competition is ever present.

In fact, it cannot be seen why price controls on petroleum could not be removed right now.

Highway limitations . . . The data projected on cars in use and consumption per car cannot be achieved on the basis of present highway capacity. This economy is built to a large extent on an unusual degree of freedom of movement and transport via highways. Many new highways must be built; many of the present ones will have to be improved and modernized. Estimated expenditures for highway construction in 1953 range between 2.7 and 3 billion dollars.

Such new transportation arteries as are constructed will have to be engineered with the same degree of skill and planning as that applied to private ventures. In fact, both the petroleum and automotive industries may find it desirable to establish a group of expert highway engineers to function in an advisory capacity to insure efficiency of highway planning, construction, and financing.

The American public will pay a fair cost for making these additional facilities available. This is adequately demonstrated by the financial success of turnpikes. Therefore, as a basic premise underlying our work, we have assumed that funds made available for highway construction will be used almost exclusively for that purpose, and that they will be wisely expended.

Industry know-how . . . Money alone will not insure the growth needed. Money must be associated with industry problem-solving know-how. This presents a two-horned dilemma: (1) broadening the training of more promising young men who will have to supervise the wider investments incident to a growth industry, and (2) retaining the productivity of some of our most successful industry members after the tax laws of the country have eliminated the economic incentive for further work.

The assumption regarding the first of these two was easy to reach. Larger capital requirements will necessitate careful supervision. This means that present management will have to train a larger number of leaders to follow them. It seemed a logical conclusion that many companies in the industry would select their more promising young men and shift them from position to position so as to provide them with the broad basis of training necessary to meet the leadership requirements of the future.

The second part of this problem is more difficult. Why should a skilled individual continue to strive for greater accomplishments when he is denied the fruits of his labor by tax laws? And yet we know that our economy must have the benefit of the productivity of this class. Hence we have assumed the continued active contribution of the most successful persons of our indus-

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try, even though we appreciate that their present economic incentives are grossly inadequate.

Labor relations . . . The existence of monopoly places a deadening hand upon a company, an industry, and upon the total economy. One of the greatest satisfactions I have obtained during my life as an economist in the oil industry is the deep conviction that it is ruled by strong, keen competition. I do not believe that an objective student can study the behavior of this industry and reach any other conclusion. Strong competition must continue if the industry is to grow.

Management-labor relationships in our industry have traditionally been on a local or, at the widest, on a company basis. This has been conducive to progress, as evidenced by wages paid and employe benefits received as fine as are enjoyed in any industry. But efforts have been made to substitute bargaining on an industry-wide basis. When industry-wide negotiations come into existence, there is an ability to extort something from the public, whether this ability is exercised or not. Interruptions of operations because of labor-management disagreement when on an industry-wide basis are in fact actions against the public.

There are competitive advantages incident to good labor-management relationships. Many in this industry are most anxious to see these advantages preserved both for labor and management. For this reason, we assumed that the general pattern of labor relationship would not change.

Divorcement . . . Competition in the market over a period of many years has built an industry structure designed to meet best the needs of the market. In many cases individual firms have worked toward an integrated pattern for the purpose of supplementing the market organization function of competition. This has resulted in various degrees of integration on the part of the vast majority of firms engaged.

I recognize that many organizations feel that the controversy involving integration does not touch them, but it does — either through ownership of transportation facilities, ownership of retail outlets, or ownership of an interest in more than one phase of the industry.

There is a suit now pending which seeks to force a segregation of marketing from other phases of the industry. None of us knows how far this effort will go. We are confident that it is an effort to modify a structure which has been built as a result of competition in the industry. It pleads that additional curbs, or barriers, to the free flow of capital and effort be introduced with respect to the petroleum industry. Therefore, if atomization of this industry results from either judicial or legislative action, the forecast which has been presented is no longer valid.

Reward to capital . . . This is an extremely complex subject to attempt to cover in a brief paragraph. Normally, we think of the claimants upon a productive capacity of an economy as being labor, capital, government, and consumers. Labor receives a wage for its hire; capital receives an interest or dividend; the Government receives its portion through taxes; and the consumer should receive his portion through greater real purchasing power of the dollar because of lower prices. But all laborers and all providers of capital are also consumers. Therefore, it is difficult to segregate the consumer's share of the output of goods and services. In reality, if we recognize this overlapping, we could say that the claimants are but three, viz., labor, capital owners, and Government. Of these, Government has received the greatest rate of increase through higher and higher taxes. Labor has received an increasing proportion of gross national production. The providers of capital have received a diminishing proportion.

The essentiality of tremendous capital outlays on the part of this industry have already been seen. To achieve this growth is to the benefit of labor, Government, and the providers of capital. A more equitable sharing of the fruits of production is a prerequisite to continued growth. Rewards to capital are believed to have passed the low level, and the future will see increased interest rates. Hence the assumption is made that the capital-supplying segment of our society will be more adequately compensated in the future, and that a better-balanced participation in gross national production among capital, labor, and Government will come into being.

Conclusion

I am sure it is realized that the authors alone could not have prepared all of the supporting evidence reviewed. There have been many collaborators, both in the company and outside. We should like to express our appreciation to them for their invaluable assistance.

But, as to the forecast, we feel that there must be a word of caution. The industry alone cannot insure accomplishment of these objectives. If the American people will create an environment characterized by monetary stability, free prices, intelligent labor relationships, and a sound highway-development program, this industry will supply the petroleum needed.

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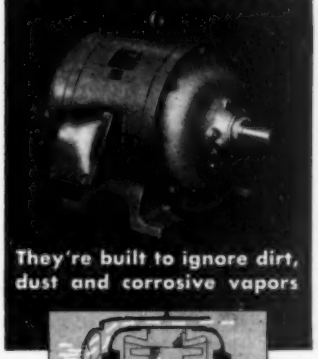

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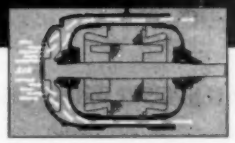

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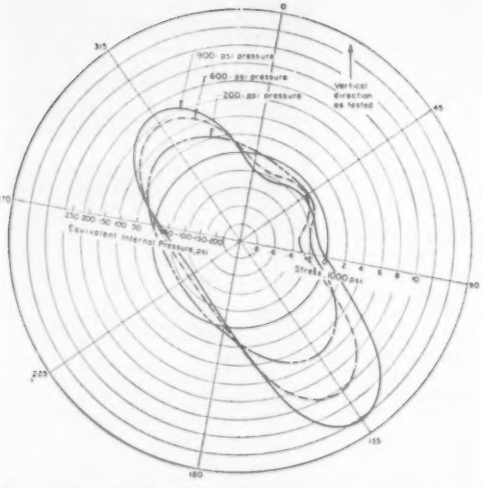

Fig. 1—Circumferential bending stresses in air at various pressures in the pipe subsequently buried in sand.

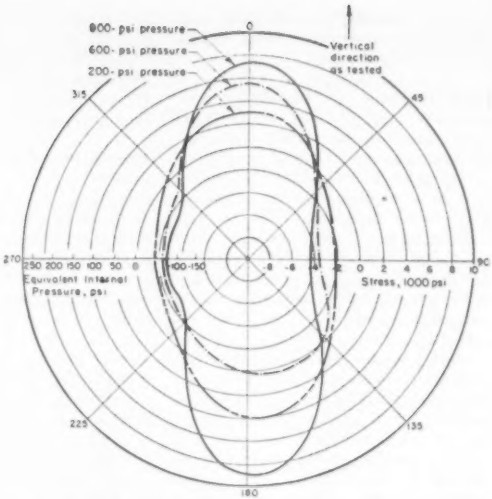

Fig. 2—Circumferential bending stresses in air at various pressures in the pipe subsequently buried in clay.

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Stress Failure in Big-Inch Gas-Transmission Pipe

Small flat spots and dents cause large local bending stresses on application of internal pressure; proof-testing pressure should be 150 psi. higher than maximum operating pressure.

by J. W. Lodge* and G. K. Manning†

IN recent years there have been instances when large-diameter gas-transmission pipe failed after installation. In some cases the pipe had previously survived a mill test at considerably higher internal pressure than that at which it failed.

A study of the stresses in short sections of buried pipe was undertaken to aid in understanding how the stresses developed after installation may exceed those developed during the mill test, and to determine how these stresses may vary from day to day and month to month after the pipe line has been placed in service.

Preparation of Pipes for Tests

Two 25-ft. lengths of A.P.I. Grade X46 electric-weld line pipe from a single heat were used in the study. The pipe was nominal 20-in. o.d., with a ¼-in. wall. Accurate measurements, made for the purpose of stress calculations, indicated a wall thickness of 0.265 in.

The pipes were forced out-of-round by placing them between the flat plates of a hydraulic press and applying a force across a diameter. The weld lines were placed midway between the major and minor axes. The force was applied through a sufficient distance to cause yielding of the pipe wall and produce a permanent set of approximately 0.4 in. between the major and minor axes of the pipe cross-section.

The pipes were given this shape in order to determine experimentally the magnitude of the bending stresses superimposed upon the circumferential stresses as a flattened pipe is pressured. Much of the flattening developed by squeezing the pipe between platens is a matter of flat spots at each end of the minor axis. It, at least, approximates the type of out-of-roundness which may develop during handling and installation of the pipe line.

Drawn steel heads approximately 6 in. in length were welded to the ends of the pipes. The heads contained suitable outlets for filling, pressuring, and measuring the internal pressure. A ¼-in. pipe, sealed at the lower end, was inserted through one of these outlets in each pipe in such a manner that the temperature of the water during each pressuring operation could be measured.

The major and minor axes of the pipes were located by micrometer measurements of the outside diameter. Pairs of strain gages (one longitudinal and one transverse) were installed at intervals of 45° around the circumference of the pipe. Three such rings of 16 strain gages were installed on one pipe, and two such rings were installed on the other pipe. Baldwin SR-4, Type A3, strain gages with a gage length of ⅛-in. were used.

Preparation of surface . . . The surface of the pipe was prepared for installation of the gages by polishing with abrasive paper until all oxide and

*Principal metallurgist, and †supervisor, metallurgical engineering, Battelle Memorial Institute, Columbus, Ohio. Presented at thirty-second annual A.P.I. meeting.

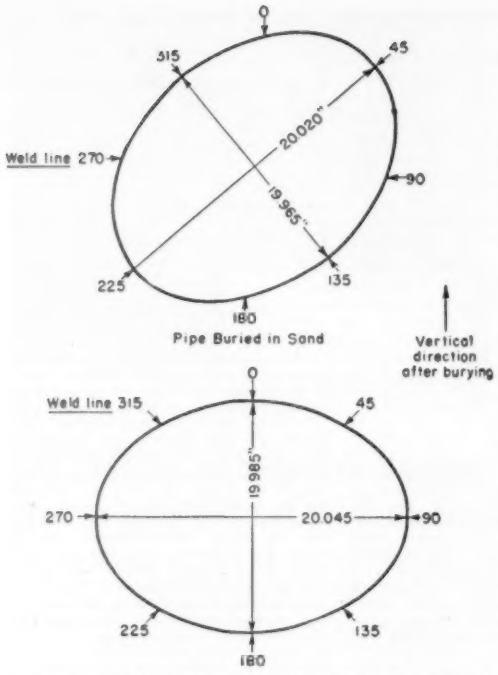


Fig. 3—Shape of pipes before burying and orientation in the ground.

scratches were removed. The prepared surfaces were wiped repeatedly with clean pieces of acetone-soaked cotton until no discoloration could be detected on either the pipe surface or the cotton. A thin layer of Duco cement was placed on the prepared surface of the pipe and the bottom surface of the SR-4 gage. The gage was positioned on the pipe, and the excess cement was forced out by a rolling action of the finger.

A special effort was made to retain the thinnest possible layer of cement between the pipe and gage without applying so much pressure that the gage would be damaged. This practice is believed to be important in obtaining reliable results.

Plastic-sheathed telephone cables, containing 22 individually plastic-covered 22-gage copper wires, were used for lead wires. Each ring of gages was served by a separate cable that was anchored and wired. Lead wires were connected to the gages by use of rosin-core solder. Rubber tape was placed on the pipe beneath the soldered connections to prevent the latter from contacting the pipe and causing a short circuit.

After the gages had air-dried for several days, the pipe at the location of the gages was heated to 120° F. by use of infrared bulbs and held at temperature for 2 hours. While still at temperature, the gages, lead wires, and open ends of cables were water-proofed by coating them with molten wax* applied with a paint brush.

Protective caps . . . Protective metal caps drawn from 22-gage sheet steel were then placed over each gage of both rings of the pipe which had only two rings of gages, and over two rings of the pipe with three gages. The shape of the protective caps was designed to bridge the gage wires and to prevent external pressures from bearing directly upon the gage, especially such concentrated forces as might be expected from a sharp stone in the soil contacting the gage. The caps were not used on the gages in one ring in order to determine whether local pressure on the gages by sharp stones was a problem.

After the caps had been positioned, the wax coating was built up by the application of molten wax in the same manner as before. It became apparent later that local pressure by stones was not a problem. The ring without the caps gave equivalent data and, therefore, no further reference is made to the caps.

The lead wires in the other ends of

*The wax employed proved to be quite satisfactory for this purpose. It was Petrosene "A" produced by the Socony-Vacuum Oil Co., Inc.

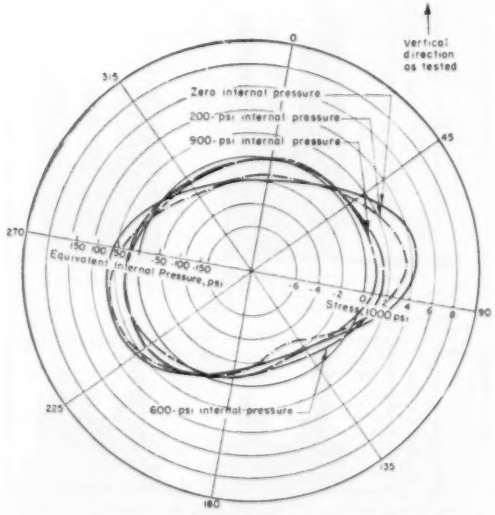


Fig. 4—Bending stresses in pipe buried in sand, resulting from the weight of the backfill (first pressuring after burying).

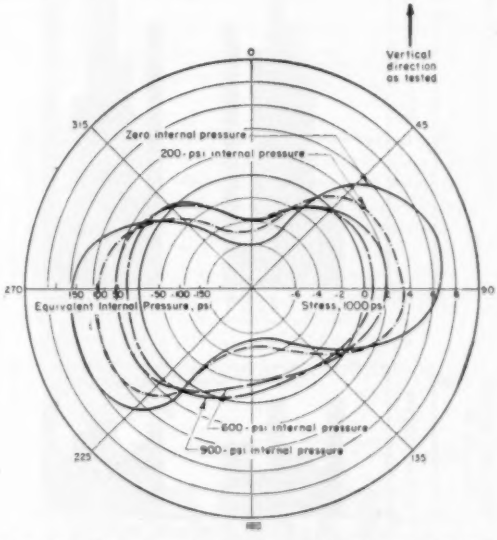


Fig. 5—Bending stresses in the pipe buried in clay, resulting from the weight of the backfill (first pressure after burying).

the cables were connected to the strain indicator through multiple-contact low-resistance switches.

The pipes were filled with water, and reference readings were made on each gage under conditions of zero internal pressure. The internal pressure was then increased by pumping oil into the pipe with a hand-operating emergency pump used on the hydraulic system of an airplane. Pressure was measured with deadweight-type gage.

During the first pressuring of the pipes in air, strain measurements were made at 100-psi. intervals of pressure as the pressure was increased to a maximum of 1,100 psi. Measurements were also made at 900, 800, 600, 400, 200, and 0 psi. as the pressure was released. The combined bending stresses and hoop stresses exceeded the yield strength of the material at many locations, and caused the metal to flow plastically. As a result, after the first pressuring in air, it was found that the difference between the major and minor axis had decreased from about 0.40 in. to 0.060 in.

The purpose of pressuring to 1,100 psi. on the first pressuring was to cause the metal to flow where it would, and to insure elastic behavior of the pipes at the lower maximum pressure used in subsequent tests.

The pipes were pressured a second time in air to 1,050 psi. Strain measurements were again made at the same intervals of pressure as the first pressuring. The purpose of this second pressuring was to make certain that the pipes were behaving elastically and to calibrate the pipes.

When a perfectly round pipe is subjected to internal pressure, the surface of the pipe wall is uniformly stressed in a circumferential direction in accordance with the relationship:

$$\sigma_c = \frac{2 \times D_i^2 \times P}{D_o^2 - D_i^2} \quad (1)$$

Where:

σ_c = circumferential stress
P = internal pressure
D_i = inside diameter
D_o = outside diameter

*This value is based on the formula for thick-wall tubing derived by Timoshenko in Strength of Material, Vol. II, p. 236. The formula for thin-wall tubing could have been used in this case without an important error. If the thin-wall formula ($\sigma_c = PD_i/2t$, where t = the wall thickness) is used, then σ_c = 37.7 P. On occasions the D in the formula for thin-wall tubing is taken as the outside diameter. This does lead to an appreciable error, because one would then conclude that σ_c = 38.8 P.

For the particular pipe used:

$$\sigma_c = 36.3\ P$$

The longitudinal stress in a perfectly round pipe capped on both ends is:

$$\sigma_l = \frac{D_i^2 \times P\dagger}{D_o^2 - D_i^2} \quad (2)$$

Where:

σ_l = longitudinal stress

For the particular pipe used:

$$\sigma_l = 18.2\ P$$

The theoretical circumferential strain in a perfectly round pipe may be cal-

†The relationship is derived by equating the force in a longitudinal direction caused by the pressure ($P \times \pi D_i^2/4$) and the force resisting pressure [$\sigma_l \times (\pi D_o^2/4 - \pi D_i^2/4)$]. It is reasonable to question whether, after burying the pipe, some of the longitudinal force may not have been absorbed by the soil's pressing against the capped ends. Analysis of the strain data, however, indicated that the force absorbed by the soil in either a longitudinal or circumferential direction was insignificant. The longitudinal stress in a pipe line is different from that in a short length of pipe capped at both ends. In the case of a pipe line it has been shown that the longitudinal strain is zero. The soil friction prevents movement in the longitudinal direction. Under these conditions, $\sigma_l = \mu \times \sigma_c$, where μ is Poisson's ratio.

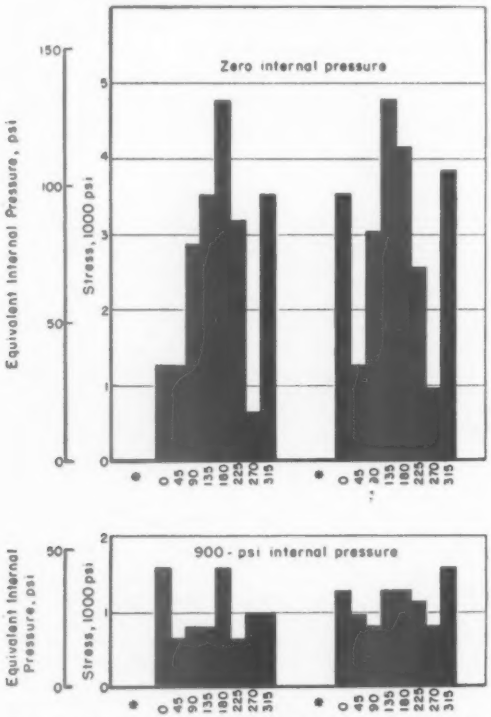


Fig. 6—Variations in circumferential bending stresses with successive pressurings of the pipe buried in sand.

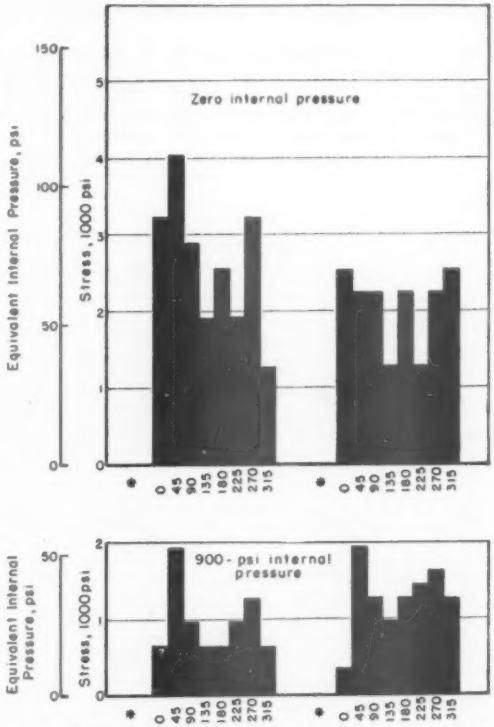
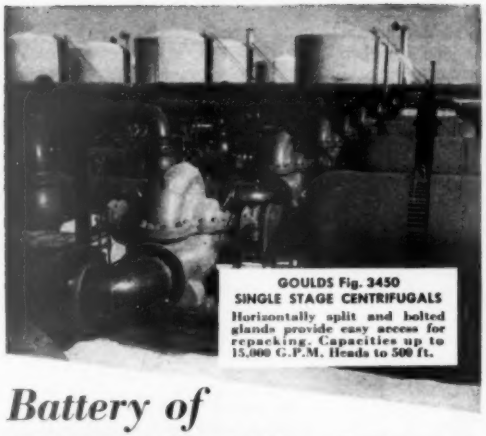


Fig. 7—Variations in circumferential bending stresses with successive pressurings of the pipe buried in clay.



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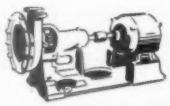

GOULDS Fig. 3705
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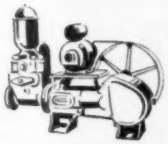
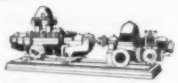


GOULDS Fig. 1813
High-quality "New Pyramid" double-acting piston pumps. Six sizes. Capacity ranges from 7 to 58 G.P.M. Heads up to 580 ft.



GOULDS Fig. 3360
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culated by substituting Equations 1 and 2 for σ_1 and σ_2 in the equation:

$$\epsilon_c = \frac{1}{E}(\sigma_c - \mu\sigma_l) \qquad (3)$$

Where ϵ_c is the circumferential strain in a round pipe; E is the modulus of elasticity [(29.6) (10^6) psi.]; and μ is Poisson's ratio (0.28).

For the particular pipe used:

$$\epsilon_c = 1.06 \times (P)\ (10^{-6})$$

The circumferential bending strain may then be found by subtracting the theoretical strain for a round pipe (ϵ_c) from the observed strain values. This difference is called ϵ_{bc}. The bending stress in a circumferential direction at the outer surface of the pipe may then be calculated by use of the formula:

$$\sigma_{bc} = \frac{E \times \epsilon_{bc}\ \ddagger}{(1 - \mu^2)} \qquad (4)$$

‡The equation is derived by recalling that:

$$\epsilon_{bc} = \frac{1}{E}(\sigma_{bc} - \mu\sigma_{bl})$$

And

$$\epsilon_{bl} = \frac{1}{E}(\sigma_{bl} - \mu\sigma_{bc})$$

$$\sigma_{bl} = E \times \epsilon_{bl} + \mu\sigma_{bc}$$

Then:

$$\epsilon_{bc} = \frac{\sigma_{bc}}{E} - \frac{\mu}{E}\epsilon_{bl} - \frac{\mu^2\sigma_{bc}}{E}$$

But the longitudinal strain component (ϵ_{bl}) at the outside pipe surface due to a circumferential bending moment (σ_{bc}) must be zero. This is true because both the inside and outside surfaces must undergo the same strain in a longitudinal direction, and because the inside and outside strains must also be equal in size but opposite in sign. These conditions can only be met if $\epsilon_{bl} = 0$.
Therefore:

$$\epsilon_{bc} = \frac{\sigma_{bc}}{E} - \frac{\mu^2\sigma_{bc}}{E}$$

And

$$\sigma_{bc} = \frac{E \times \epsilon_{bc}}{(1 - \mu^2)}$$

An out-of-round pipe is forced towards a round position with increasing internal pressure which causes bending stresses to be superimposed upon the normal hoop stresses of a round pipe. On the outer surface of the pipe where the gages were located, the bending stress may be either tensile or compressive, depending upon the specific location relative to the shape of the cross-section of the pipe. The outer surface of the pipe at the minor axis is subjected to the highest tensile stress, and at the major axis to the lowest tensile stress.

In the case of an elliptical pipe, the bending stress at the minor axis will be equal in magnitude but of opposite sign to that at the major axis. In the case of pipe in which the out-of-roundness is a matter of flat spots or even dents in the pipe wall, symmetry does not need to exist. It is only necessary that the summation of the bending moments about the circumference be zero, and it is possible for the very high bending moments in the vicinity of a flat spot to be balanced by relatively small moments of opposite sign in most of the pipe wall.

Effect of Out-of-Roundness on Bending Stresses

The results of measurements made during the second pressuring in air were treated in the manner indicated, and the circumferential bending stresses present at the outer surface of the two pipes at 900 psi., 600 psi., and 200 psi. internal pressure are shown graphically in Figs. 1 and 2. The maximum bending stress observed in the pipes at 900 psi. internal pressure (14,000 psi. for one of the pipes) was much higher than would be found in an elliptical pipe which has a difference of only 0.060 in. between the minor and major axes.

The longitudinal bending stresses caused by camber along the length of

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the pipe were calculated in a similar manner, but were found to be less than 1,000 psi. as might be expected for a straight pipe. They have not been reproduced here.

Method of burying pipes . . . One of the pipes was buried in a ditch 36 in. wide and 50 in. deep, which was dug in a clay-type soil. It was completely covered by backfilling with the soil which had been removed from the ditch.

A ditch 60 in. wide and 70 in. deep was dug for the other pipe; 20 in. of sand was placed in the bottom of the ditch before the pipe was lowered into position. The ditch was then filled with sand. A minimum of 20 in. of sand around the pipe was considered necessary to assure freedom of the pipe from influence of the surrounding clay soil. The pipes were oriented in the ditches relative to their cross-sectional shape, as shown in Fig. 3.

Effect of Unequal Soil Pressures on Bending Stresses

After the pipes had been buried and backfilled to simulate field conditions, strain measurements were made at all gage positions at zero internal pressure. It was found that a drift in the strain-gage values had been caused by moving the lead cables when the pipe was buried, and it was necessary to add 40 microinches per inch to each strain-gage value after burying. The change in strain, at each gage position, from the zero reference measurement obtained at the same position when the pipe was at zero internal pressure surrounded only by air is caused by the weight of the backfill on the pipe. The corresponding stresses in the pipe wall were calculated from such strains, and are shown graphically in Figs. 4 and 5 by the "zero internal pressure" curve.

The change in stress around the circumference of the pipe shows that the weights of the soil tended to flatten the pipe, increasing its axis in the horizontal direction and decreasing the axis in the vertical direction. The sand caused less flattening and less bending stress than did the clay, and it is apparent that the sand acted somewhat more like a fluid than did the clay. The pattern of the bending stress does not appear to be influenced to any appreciable degree by the relative orientation of the original out-of-roundness of the pipe.

The bending stresses at the pipe surface caused by the unequal soil pressures are quite large at zero internal pressure. The maximum bending stress in the pipe buried in sand was approximately 4,500 psi., which is equivalent to the hoop stress resulting from 125 psi. of internal pressure. The maximum bending stress of 7,000 psi. in the pipe buried in clay is equal to 190 psi. of internal pressure.

It can be shown that, at zero, internal pressure, an unequal soil pressure which is constant across a diameter of the pipe will produce a circumferential bending stress given by the equation:

$$\sigma_{bc}\ (\text{max.}) = \frac{3P_s D_o^2}{8t^2}$$

Where:

σ_{bc} (max.) = maximum bending stress
P_s = unequal soil pressure
D_o = outside diameter
t = wall thickness

Using the observed maximum bending stresses to calculate the unequal soil pressure, $P_s = 2.1$ psi. for the pipe buried in sand, and $P_s = 3.3$ psi. for the pipe buried in clay. Inasmuch as the backfill over both pipes was 30 in., the values for P_s appear reasonable and, consequently, the bending stresses observed are within the range which might have been predicted.

When the pipe is pressured in the soil, the bending stress from unequal soil pressure decreases markedly. This is shown in Figs. 4 and 5 by the curves marked 200 psi., 600 psi., and 900 psi. The curves were determined by sub-

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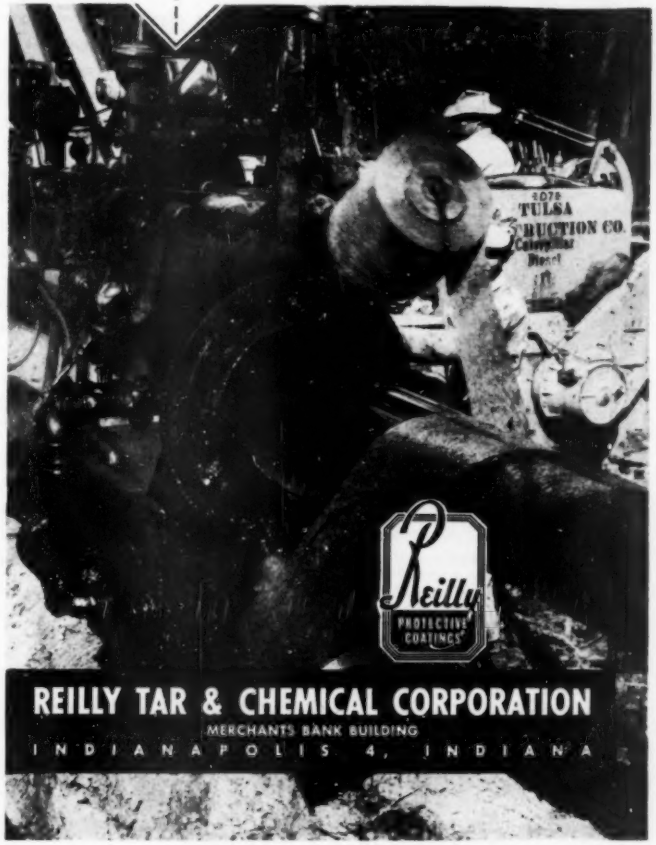

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tracting the bending stress observed in air at each pressure from the bending stress observed after the pipe had been buried. At 900 psi. internal pressure, the bending stress due to unequal soil pressure was a maximum of about 1,000 psi., equivalent to 28 psi. internal pressure for both of the pipes.

Proof testing in the field introduces the question of what margin of pressure over the intended operating pressure should be used in the proof test. There are on record examples of pipe lines which failed at pressures which were less than the highest pressure to which the line had previously been subjected. This suggests that the bending or restraining forces of the soil are changing from time to time, resulting in a variable stress system.

In order to determine the magnitude of such variations in the stress system, the pipes were pressured 10 times over a period of a year. The total range in strain values for each gage at 0 internal pressure and at 900 psi. internal pressure was determined. The longitudinal strain varied only slightly from one pressuring to the next, but the circumferential strain—particularly in the case of pipe buried in clay—changed appreciably.

The total range for the circumferential gages is shown in Figs. 6 and 7. It can be seen in Figs. 6 and 7 that the fluctuation in circumferential stress is greater at 0 psi. than it is at 900 psi. of internal pressure. This is what might be expected because it has already been noted that unequal soil pressures produce larger bending stresses in the pipe wall at 0 pressure than at 900 psi. internal pressure.

The largest variation in circumferential stress at any gage position in the pipe buried in sand was 4,800 psi., at 0 internal pressure. At 900 psi. the same pipe showed a maximum variation of 1,600 psi. equivalent to an internal pressure of 44 psi. The pipe buried in clay, although exhibiting less variation at 0 internal pressure than did the pipe buried in sand, showed a greater stress variation at 900 psi. internal pressure.

At 900 psi. internal pressure a range of circumferential bending stress as great as 1,900 psi. (equivalent to 52 psi. internal pressure) was observed between the various pressurings.

Although the variations in stress measured in these particular pipes at pressure are not sufficiently large to explain all field failure, the tests serve to demonstrate that such fluctuations in stress do exist.

The conditions of these tests do not necessarily represent the extremes of all field conditions. The pipes were buried in a horizontal position in level ground. It may be that the variation is larger when the pipe is buried along the side of a hill. It may also be that, had the test pipes been pressured 100 times after burying over a period of several years, the variation would be found to be somewhat larger than that indicated.

Conclusions

It becomes apparent that small flat spots and dents in thin-wall large-diameter pipe will cause large local bending stresses when internal pressure is applied to the pipe. These bending stresses are very likely to cause local plastic deformation the first time pressure is applied to the line. This, in turn, suggests the importance of adequately proof testing a pipe line before it is placed in service, and in doing it in such a manner that, in the event of a failure, there will be no extensive damage.

In addition, it was found that the stress in a pipe wall fluctuates somewhat because of changing soil pressures. These variations were found to be equivalent to as much as 50 psi. internal pressure, and it seems reasonable that the proof-testing pressure should be at least 150 psi. higher than the maximum operating pressure.

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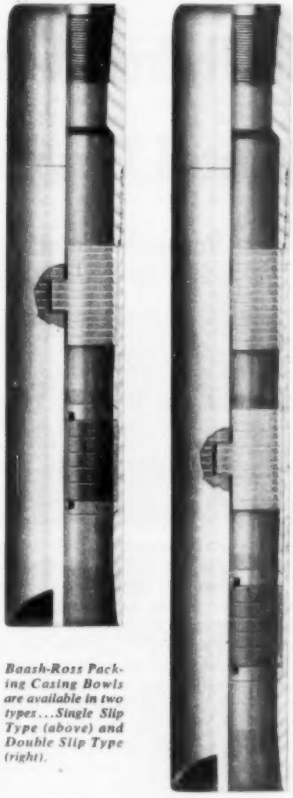

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Thermodynamic Properties Of Hydrocarbons and Related Compounds

. . . a Research Project 50 report

by K. S. Pitzer* and R. R. Brattain†

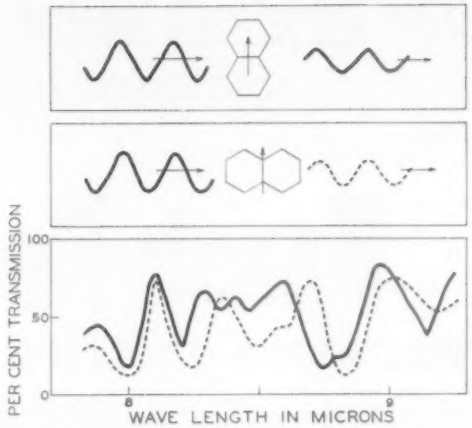

Fig. 1—Infrared absorption spectra of naphthalene single crystals with polarized incident radiation. The two spectra are for two different orientations of the naphthalene crystal with respect to the plane of polarization of the incident radiation.

RESEARCH sponsored by A.P.I. Research Project 50 is aimed at a better understanding of the thermodynamic properties of hydrocarbons and related compounds in terms of molecular structure. Internal molecular forces will be measured, and from this information thermodynamic properties will be calculated.

The substances chosen for study will be selected on the basis that a fundamental understanding of their structures and thermodynamic properties will make possible the calculation of similar information for a large number of structurally related molecules of interest in petroleum processing.

This approach should be particularly fruitful in the field of hydrocarbons, inasmuch as hydrocarbons as a class consist essentially of large numbers of molecules with close similarities of structure. Thus, for example, practically all types of interatomic forces within long paraffin molecules are already present in normal pentane. Consequently, if these forces can be well enough understood for pentane, the properties of all higher hydrocarbons can be calculated in reasonable approximation.

Often the best method of determining the contribution made by a particular atomic grouping such as a methyl group to the over-all behavior of the molecule is to compare the properties of the molecule with a related molecule whose only difference in structure is connected with the particular atomic grouping of interest. This tool will also be used by including, whenever appropriate, a study of the changes which occur in the thermodynamic properties of hydrocarbons as a result of converting the hydrocarbon to a simple hydrocarbon derivative.

Research Project 50 is the newest project under the sponsorship of the Advisory Committee on Fundamental Research on Composition and Properties of Petroleum, having been started only in July of this year. Consequently, it has no history or accomplishments of its own to report; but, inasmuch as it grew naturally out of activities already in existence at University of California, both a brief history of its origin and a brief illustration of the type of work planned can be drawn from these previous activities.

Cal Long a Leader

The activities from which Project 50 grew are the University of California investigations along the lines summarized previously herein and the branch of Research Project 44 which has been active at University of California for several years. Although Project 44 supported only theoretical correlations and calculations, there was an active program of related experimental measurements being carried on by the university.

University of California had long been a leader in low-temperature thermodynamic investigations, particularly in the determination of entropies by the integration of heat-capacity data from the absolute zero of temperature. This method was applied to hydrocarbons and their simple derivatives, beginning about 1935. In addition to calorimeters for condensed phases, a flow calorimeter for vapor-heat capacity measurements was built about 1940.

Of essentially equal value with such direct measurements of thermodynamic values are spectroscopic measurements because such measurements are extremely useful in determining the forces within molecules. Infrared-absorption spectroscopy has been emphasized in the work at University of California, although equipment is available there for the measurement of raman, ultraviolet, and fluorescence spectra.

All of the internal vibrations of a molecule contribute to its thermal properties, but the vibrations of low frequency contribute the most. Determination of these low-frequency vibrations is not possible with the usual infrared prism spectrometers because the available prism materials do not transmit energy in this frequency region; consequently, the usual infrared equipment has been supplemented at University of California by the construction of an automatic-recording grating spectrometer with which these low frequencies can be studied.

There are only a very few grating spectrometers of this type in the world, and the availability of this instrument should be of major significance to the work of Project 50. It has already been used to study vibrational frequencies as low as 130 wave numbers.

From the work on correlation and calculation of thermodynamic data sponsored by Project 44, and from the aforeoutlined experimental program at University of California, grew quite naturally a project whose major aim is to understand the forces acting in the principal molecular functional groups and to apply this knowledge to a better understanding of the thermo-

*University of California, Berkeley, and †Shell Development Co., Emeryville, Calif., and chairman, Research Project Advisory Committee. Presented at thirty-second annual A.P.I. meeting, Chicago.

dynamic properties of hydrocarbons and related compounds. Such a program is, of course, a part of the larger program of research being sponsored by the American Petroleum Institute; and, as its results should be of particular interest to Projects 44 and 48, close cooperation and coordination with these projects has already been arranged.

As mentioned earlier, Project 50 was activated on July 1, 1952, so the work of the project cannot be illustrated with research already done. However, it is possible to illustrate the necessity for, and the coordination of, a number of experimental techniques in any attempt to understand the thermodynamic properties of a substance on the basis of its molecular structure.

The research chosen as an illustration is the study of the structure of naphthalene to enable calculation of its thermodynamic properties, which was done jointly by the University of California and Project 44. The key to this research was the identification of the fundamental vibrations of the naphthalene molecule, and this identification is difficult in the case of such a complicated structure; e.g., there are 48 fundamental modes of vibration of the naphthalene molecule.

Identification of these vibrations would permit calculation of their contributions to the thermodynamic properties of naphthalene as well as furnish considerable additional detailed information regarding the structure of naphthalene.

First, all available data were reviewed and evaluated. Nineteen studies of the raman spectrum and eight studies of the infrared spectrum of naphthalene were available, and this group included determinations of the spectrum of naphthalene in solution as well as in the liquid and solid states. These studies determined the frequencies of many of the vibrational modes, and the intensities of the infrared-absorption bands or raman lines serve as a basis for selecting many of the fundamental vibrations from among all of the vibrations mapped.

In addition to these 27 determinations of the spectrum of naphthalene, 3 determinations had been made of the polarization factors of the raman lines. From these polarization measurements, it is possible to identify the frequencies which are associated with vibration motions which do not disturb the molecular symmetry, and by application of this principle it was possible to identify positively 8 of the 48 fundamental vibrational modes.

The raman spectrum of naphthalene single crystals had also been determined with polarized light as the exciting radiation; and the results of this study made it possible to segregate some of the known vibrational frequencies into two classes, viz., those due to an in-plane vibrational motion and those due to an out-of-plane vibrational motion.

Even with the rather large amount of experimental data summarized previously, it was not possible to make a positive assignment of the observed infrared absorption or raman frequencies to the corresponding fundamental modes of vibration. An assignment could be made, but not with the confidence which is desirable if the assignment is to be used as the basis for thermodynamic calculations. Consequently, additional experimental studies were undertaken in order to remove the ambiguities.

Up to this point the experimental bases for the theoretical calculations were all essentially spectroscopic, and it appeared essential to anchor these theoretical calculations on some independent data, viz., calorimetric data. A vapor-phase calorimeter originally designed for use with liquids with high vapor pressures was modified to allow measurements on naphthalene. The heat of vaporization and the vapor-phase heat capacities were then measured. These data, combined with the already available solid and liquid-heat capacities and heats of transition, pro-

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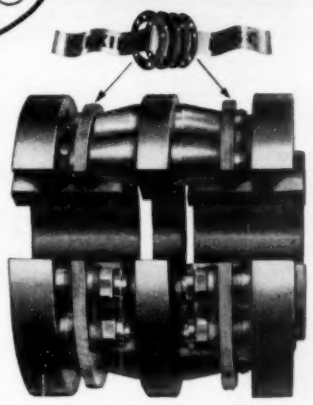

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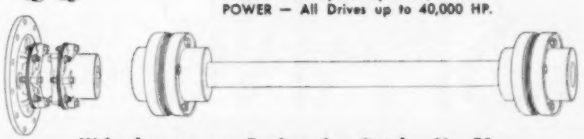

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vided bases for calculating the third-law entropy of gaseous naphthalene.

Additional data were also obtained from further spectroscopic work. The shape or contour of the absorption bands in the infrared spectrum of a vapor sample offer an opportunity to identify the vibration type with which these absorption bands are associated. The knowledge of the structure of naphthalene, acquired up to this point in the work, indicated that about six of the more intense infrared-absorption bands in the spectrum of naphthalene vapor should be useful for this purpose. This indication was proved to be correct by the infrared spectrum of naphthalene vapor obtained by using a special high-temperature infrared cell designed and constructed for this purpose.

Earlier it was mentioned that one of the most powerful tools for determining the effect of a particular atom or group of atoms is to substitute some other atom or some other group for the atom or group of atoms in question. The simplest of these techniques, viz., the substitution of deuterium for hydrogen, has been a favorite tool of the spectroscopists to aid in identifying those absorption frequencies due to vibrational modes dominated by the motions of hydrogen atoms. This technique was applied to this problem by synthesizing naphthalene-d_1 and naphthalene-d_8 and obtaining their infrared spectra in the vapor, solid, and solution phases. Attempts to synthesize naphthalene-d_2 and naphthalene-d_4 in order to obtain additional data were unsuccessful.

Direction of Principal Motion

The various internal modes of vibration of a polyatomic molecule can be divided into types on the basis of the direction of the principal motion involved in the vibrational mode. Full benefit cannot be taken of this fact in interpreting the usual infrared spectra where the molecules in the sample are completely randomly oriented and where the direction of the electric vector of the incident electromagnetic radiation is also completely randomly oriented. However, if polarized infrared radiation is used as the incident radiation, and if the sample is a single crystal, the foregoing fact can be used to acquire considerable additional information concerning the nature of the vibrational modes.

The modes in which the principal motion is parallel to the direction of the electric vector will react with the incident radiation in a quite different manner from the modes in which the principal motion is perpendicular to the electric vector. Reaping the full benefit of these special spectra requires the development of a model; i.e., plausible structures for the naphthalene molecule and the naphthalene single crystal are tested by theoretical calculations until one is found which will explain the spectra.

The polarized spectra of two distinct crystallographic planes of naphthalene and of one plane of naphthalene-d_8 were obtained, and these in combination with the correct model made it possible to get a detailed division of the vibrations according to type. Fig. 1 shows the quite remarkable differences between infrared-absorption spectra obtained from naphthalene molecules which are oriented in different directions with respect to the electric vector of the incident electromagnetic radiation.

The short sections of spectra shown in the bottom section of the illustration correspond to the two orientations of a naphthalene molecule shown previously herein. Polarized incident radiation was used in another manner to furnish an independent check of the validity of the model proposed for the interpretation of the single-crystal spectra. Polarized infrared-absorption spectra of mixed crystals, naphthalene in

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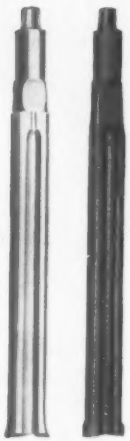

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anthracene, and naphthalene-d_8 in naphthalene were obtained, and these results were consistent with theoretical calculations based on the structural model used for the interpretation of the single-crystal spectra.

Two additional items complete the experimental work done on this problem. First, the grating spectrometer described previously herein was used to obtain the far infrared spectrum of naphthalene in order to locate the thermodynamically important carbon skeletal vibrations. The values of these frequencies are not easily calculated from other data; and, inasmuch as they occur in a spectral region which is not accessible with the usual prism spectrometers, the grating spectrometer made a valuable contribution to this problem. Second, an analog computer capable of handling 10 simultaneous equations was designed and constructed in order to reduce the time which it is necessary to spend on theoretical calculations.

In review, this appears to be a complicated and imposing piece of research. Actually, the interest and efforts of 12 individuals at University of California have directly contributed to one phase or another of the program outlined previously herein. Four publications have already resulted from this study, and three more are in press or in preparation.

Two questions appear to be important. First, what scientific advances have been made as a result of this work? The structure and thermodynamic properties of naphthalene are now available. This is, however, only a small fraction of what has been accomplished.

The understanding of the structure and thermodynamic properties of naphthalene will serve as a sound basis for calculating the thermodynamic properties of naphthalene derivatives and other condensed ring aromatics which are such important constituents of petroleum. In addition to this—which was, of course, the primary object of the research—several other advances have been made. New equipment and techniques, both experimental and theoretical, have been designed and developed, and these represent an advance because they will be useful regardless of what structural problem is attacked next. Fundamental advances were also made in the interpretation of the dichroism exhibited by solids and by mixed crystals.

The other question is: "Is the naphthalene work a typical illustration of the research planned for Project 50?" It is not typical from the standpoint that naphthalene is a more complicated molecular structure than many of those which will be investigated. But it is typical because an understanding of the structure and thermodynamic properties of naphthalene opens the door to the calculation of the thermodynamic properties of a great number of related substances, and all of the materials studied by Project 50 will be chosen with this idea in mind.

Further, the work on naphthalene structure serves as a good illustration of how various experimental techniques can be applied to obtaining various data which, when fitted together, give a solution to a complicated structural problem.

It is essential that the structural problems chosen for Project 50 be carefully examined to insure that their solution will contribute to understanding thermodynamic properties on a wide scale and that they will assist in the solution of other problems. Consequently, the research program cannot be planned too rigidly far in advance; rather it must be adjusted to make maximum progress under the circumstances existing at a given time, and to make full use of the most recent data and techniques.

In line with this philosophy, one of the first systems studied will be the simple derivatives of ethane. The cause

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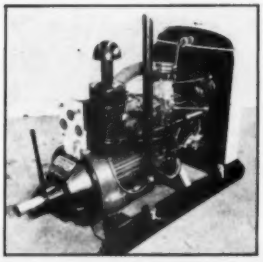

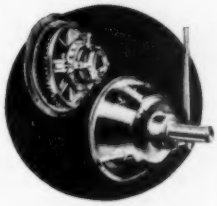

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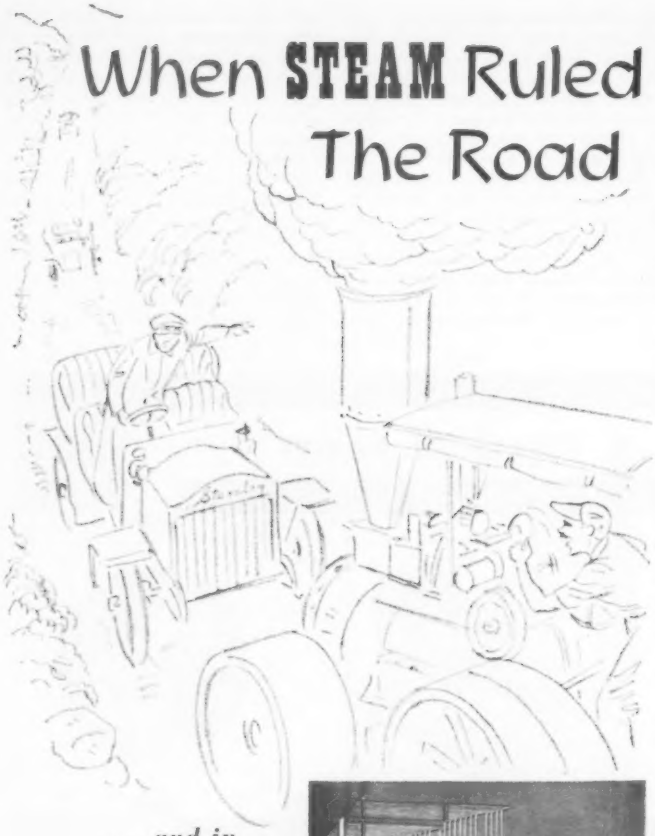

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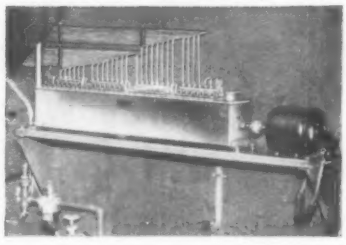

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of the potential energy associated with the internal rotation in ethane is only partly understood. By substituting halogen atoms or simple radicals for one or more of the hydrogen atoms in ethane, it should be possible to obtain a better insight into the forces between the atoms attached to adjacent carbon atoms.

Similar studies may be made on the derivatives of ethylene. Here the double bond itself resists the twisting motion of the molecule, but it is of interest to see how the double bond is affected by simple substitution.

The data to be obtained have, of course, a variety of direct applications in addition to the more theoretical ones mentioned. For example, the infrared spectra will be obtained over a greater wave-length range than before. The thermodynamic data are important in relation to chemical reaction equilibria and to physical and engineering design.

Some attention is also being given to forces between molecules. It seems possible that some further generalizations can be found with respect to the P.V.T. behavior of nonideal gases. In particular, the influence of molecular shape is being studied. The law of corresponding states is known to apply to spherical molecules such as the rare gases and methane. The extent to which a single-shape parameter will correlate the deviations of nonspherical molecules is a key subject for study.

These are the new subjects to which Project 50 is turning. A major amount of time is currently being devoted to final revisions of thermodynamic tables for Project 44 before the next bound volume of these tables is completed. Revisions of the reports on normal paraffins and new reports on the methyl (mono and di-) cyclopentenes were issued recently. Work is now being done on the branched paraffins through C_9 and on the monoolefins. These tasks should be completed soon.

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Thermofor Catalytic Reforming . . . An Answer to Demand for Higher Octane Numbers

by J. W. Payne,* L. P. Evans,* E. V. Bergstrom,† and V. O. Bowles†

VARIOUS types of catalyst are known to be selective for the reforming of petroleum naphthas. Of these, the one finally selected for development specifically for the T.C.R. process is a synthetic chromia-alumina gel. This type of catalyst has many desirable characteristics:

1. It has a "high-octane-number ceiling"; i.e., it permits reforming to high antiknock quality (F-1 100 octane number, or higher, upon the addition of 3 ml. TEL per gal.) with good yields.

2. It operates with low hydrogen partial pressure.

3. It can be readily regenerated. This can be accomplished by burning off the coke deposits. Thus wide latitude is provided for the reforming of all types of stocks, particularly the high coke-forming thermally cracked stocks, as well as broad boiling-range straight-run stocks.

4. It promotes excellent desulfurization, and the sulfur is eliminated mainly as hydrogen sulfide in the reforming gas—thus avoiding a potential air-pollution problem.

5. Finally, the catalyst is in bead form, and it possesses the high physical strength and ruggedness of the widely used T.C.C. bead cracking catalyst.

This catalyst has regeneration characteristics of marked significance in commercial application; e.g., it can be regenerated at a much lower temperature than cracking catalyst. All of the coke burns to carbon dioxide. The catalyst does not exhibit any significant oxidation - reduction phenomena. No appreciable amounts of sulfur dioxide are discharged with the flue gas for the reason that the sulfur is largely eliminated in the reactor rather than in the regenerator.

Catalytic Reforming Is Likely Method for Upgrading Low-Octane Gasoline Fractions

PART of the progress made in automotive-engine design during recent years has been founded on the ability of the petroleum industry to produce gasolines of progressively higher antiknock quality level. Except during World War II octane numbers have increased steadily over a considerable period of time, at the rate of one to one and one-half units per year, to the current average level of about 84 F-1 octane number for regular-grade and about 91 F-1 for premium-grade gasolines.

The demand for still higher octane numbers seems destined to continue, with increased emphasis being placed on high-compression-engine design. If the trend continues to the 12:1 compression-ratio level, the octane-number requirement may be in the F-1 range of 98 to 100.

This poses an important challenge for the petroleum refining industry: It means that more drastic and efficient processing techniques must be adopted to attain these high antiknock quality levels. Present octane-number levels are being met largely by catalytic cracking, supplemented by thermal reforming and cracking, and by catalytic polymerization.

The relative quantity and quality of gasoline components supplied by these operations at present are approximately:

	Per cent	F-1 Oct. No.*
Catalytic gasoline	31	98
Thermal gasolines	26	89
Straightrun naphtha (including natural)	33	84
Heavy straightrun naphtha	8	68
Catalytic polymer gasoline	2	115
	100	†89

*With addition of 3 ml. TEL per gallon.
†Pool octane number.

Although some minor increase in present octane-number levels could be effected by more extensive use of catalytic cracking and catalytic polymerization, there are obvious limitations to this course. The most effective method of attaining the substantial increase required would be to upgrade the low-octane-number components of straight-run and cracked gasolines. This requires a more selective process than the widely used thermal reforming process which gives excessive yields of gas and tar when high-octane-number levels are attained by reforming. The answer to the problem is catalytic reforming.

In anticipation of this trend, Socony-Vacuum has for several years been carrying on experimental work which has culminated in the development of the Thermofor catalytic reforming (T.C.R.) process. This work involved both catalyst research and process development—first through various types of bench-scale studies and, finally, on a 50-bbl. per day pilot-plant scale. The entire development program was conducted at Socony-Vacuum's research and development laboratories, located in Paulsboro, N. J.

Bench-Scale Studies

Two types of bench-scale units were employed in this work. One was an isothermal fixed-bed unit with a 700-ml. reactor immersed in a lead bath. Initially this unit was operated with hydrogen addition from cylinders. Subsequently it was modified to include a gas-recycle pump so that actual recycling of hydrogen-rich process gas could be studied.

The second unit was similar to the first, except that its reactor had a catalyst capacity of 2,000 ml. and it was designed to operate essentially adiabatically—thus making possible a study of heat effects during reaction and regeneration under various types of operating conditions.

Major process variables covered in this bench-scale study were pressure, gas-recycle ratio, reaction temperature, space velocity, and catalyst-to-naphtha ratio.

Pressure . . . Reaction pressures covered a range from atmospheric to 500 psig. When reforming proceeds to a given octane number, lower pressures result in a more satisfactory yield of 10-lb. R.v.p. gasoline and a higher hydrogen and coke production. Bench-scale data indicate the desirable pressure range to be between 100 and 200

*Socony-Vacuum Laboratories, Paulsboro, N. J., and †Socony-Vacuum Oil Co., Inc., New York. Presented at midyear meeting of A.P.I. Refining Division, San Francisco, 1952.

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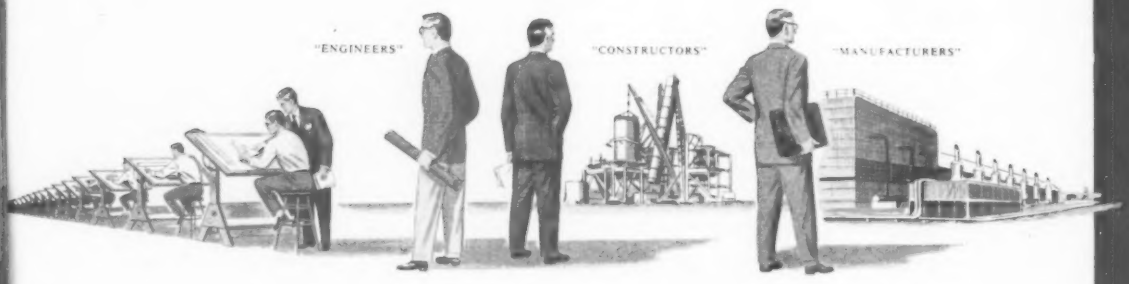

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psig.—the level within that range depending on the stock and depth of reforming.

Gas-recycle ratio . . . Gas-recycle ratios up to 12 mols of gas per mol of naphtha have been explored. As the recycle ratio is increased, coke "make" decreases appreciably and gasoline yield increases slightly, whereas the hydrogen content of the recycle gas remains fairly constant. In adiabatic operation gas recycle also aids in supplying reaction heat. Practical recycle ratios appear to be in the range of three to nine.

Temperature . . . After other process conditions are fixed, reactor temperature is the principal variable for controlling the reforming severity and octane number of the product. The temperature severity required depends on the stock, and it can range from about 950° F. on an easily reformed stock to 1,000° F. for a refractive-type stock for reforming to an F-1 octane-number level of 100 upon the addition of 3 ml. TEL per gallon.

Space velocity . . . As a means of controlling severity, space velocity is interchangeable with temperature over a fairly wide range; i.e., lower temperatures can be used with lower space velocities in order to produce the same yield - octane - number result. A space velocity of about 0.7 volume of naphtha per unit reactor volume per hour is satisfactory for the temperature range indicated previously.

Catalyst-to-naphtha ratio . . . This can be varied over a wide range, with no marked effect on product yields and quality, provided coke concentration on the catalyst does not become excessive. Because coke deposition with this catalyst is relatively low, it is possible to operate with very low catalyst-circulation rates compared to those used in catalytic cracking.

Pilot Plant

In view of the promising results obtained in the catalyst development and bench-scale investigations, extensive engineering and economic studies were made for the purpose of appraising the commercial potentialities of the process. These studies led to the third and final phase of the development program, viz., the construction and operation of a 50-bbl. per day moving bed pilot plant. This unit was erected almost 3 years ago in order to prove the important operating features of the process, and in order to provide information for the design of commercial units.

Equipment . . . The reactor is a stainless-steel vessel, with an inside diameter of 12 in.; it is 15 ft. high, and is designed to operate at pressures up to 500 psig. It is mounted inside of a 24-in.-diameter carbon-steel jacket. The 6-in. annular space between the two shells is filled with insulation so as to make the reactor essentially adiabatic. Vapor inlet and outlet manifolds are arranged so that the reactor can be operated with downward, upward, or split flow of the vapor stream. For catalyst flow, pressure pots and plug valves are provided above and below the reactor.

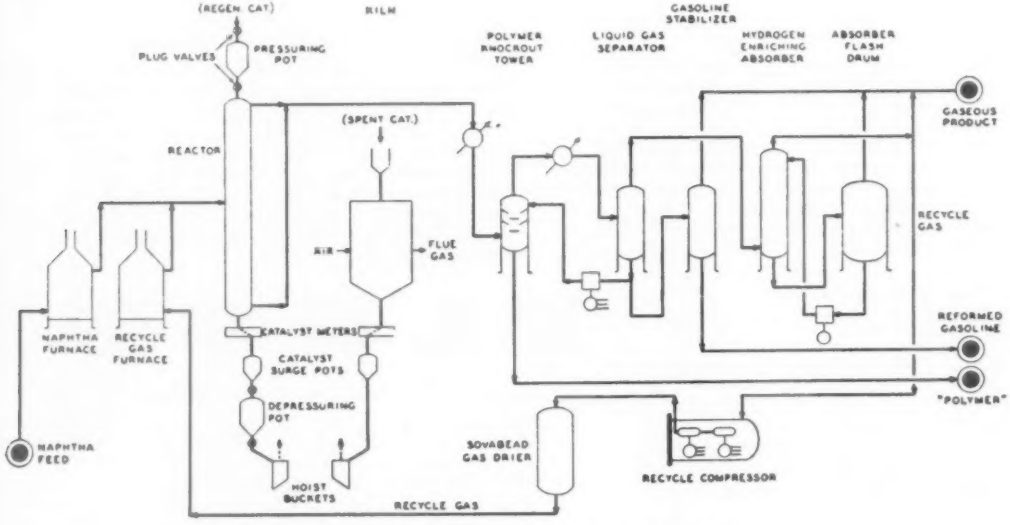
The kiln is an atmospheric vessel designed to simulate multizone regeneration of the catalyst. A skip-hoist system is provided for transfer of the catalyst between reactor and kiln. The entire structure around the reactor and kiln is about 55 ft. high.

Two gas-fired furnaces are used for separate preheating of the naphtha and recycle-gas streams. The two preheated streams are mixed just before they enter the reactor.

The product-recovery system is designed to permit study of various possible processing schemes. Equipment includes a knockout pot in which the reaction vapors are quenched so as to condense a heavy polymer cut, a water cooler and gas separator, an absorption system for the study of hydrogen enrichment, and a product - stabilizer tower.

Stock evaluations . . . Ten different types of stocks have been processed in the 50-bbl. per day pilot plant. One of these stocks, viz., a 200° to 380° F. end-point straightrun naphtha from Tibu-Petrolea (Colombia) crude, was available in large quantity at Socony-Vacuum's Paulsboro, N. J., refinery; therefore, it was used for "shakedown" operations and for extensive study of process variables.

The other stocks, obtained from several other refineries in tank-car quantities, represent potential charge stocks for T.C.R. units being considered at those plants. These stocks included both



FLOW DIAGRAM of 50-bbl. per day T.C.R. pilot plant—Fig. 1.

straightrun naphthas and blends thereof with thermal gasolines—these stocks boiling chiefly in the 200° to 400° F. range.

One stock, which comprises approximately equal parts of straightrun and high-sulfur coker naphthas from Wilmington, California, crude required reforming for sulfur removal as well as for octane-number improvement. All stocks were selected from normal refinery operations, and no special precautions were used to obtain clean fractionation.

Table 1 summarizes the properties of five of these stocks, and Table 2 gives actual pilot-plant data for reforming them under commercial design conditions to octane-number levels in the F-1 range of 96 to 100 upon the addition of 3 ml. TEL per gallon. It will be noted, in the case of the Wilmington blend, that excellent desulfurization and antiknock quality improvement are obtained, with a high product yield.

Because of the large scale of the pilot-plant operation, it was obviously possible to prepare adequate quantities of products for extensive performance tests. As shown in Table 2, the pilot-plant gasolines have a moderate olefin content, and they require only a small amount of inhibitor—up to 3 lb. per 1,000 bbl.—for acceptable stability.

Results of engine tests show that finished T.C.R. gasolines have an acceptable engine-cleanliness rating, and that they give road antiknock performance consistent with laboratory ratings of other gasolines in the same range.

The characteristics of the products obtained from the operation of the 50-bbl. per day pilot plant were essentially the same as those obtained from bench-scale operations. Also, the study of process variables in the 50-bbl. per day unit confirmed the pattern established in the bench-scale units.

Water elimination . . . It was found, in the course of the pilot-plant program, that the presence of moisture in substantial concentration in the reaction zone has an adverse effect on product yields. In order to avoid excessive moisture in this part of the system, provision was made for drying the recycle-gas stream. Adsorbed moisture or oxygen on the regenerated catalyst is automatically removed before it enters the reaction zone in the split-flow reactor arrangement.

Catalyst valves . . . As noted previously, a pressure-lock system is used to introduce regenerated catalyst into the reactor. Operating experience in the 50-bbl. per day unit—supplemented by extensive valve-wear studies under commercial design conditions through 15,000 operating cycles—has shown that lubricated plug valves with stellited surfaces perform satisfactorily. Such valves give excellent tight service for many months, with negligible wear or scoring of the seats and plugs.

Catalyst life . . . One important objective of the 50-bbl. per day pilot-plant program was to study catalyst-life characteristics. This refers to the ability of the catalyst to sustain activity and selectivity, as well as physical strength, in prolonged T.C.R. service.

Bench-scale aging tests had indicated that the catalyst activity decreased only to the extent of a 3 per cent drop in gasoline yield in equilibrating through repeated reforming-regeneration cycles. This has been confirmed in the 50-bbl. per day pilot plant, wherein one batch of catalyst has been in service for about 18 months. Despite the extreme types of operation to which this catalyst has been subjected in that period, its activity loss has been equivalent to as little as 2 per cent lower gasoline yield than fresh catalyst at the F-1 octane-number level of 98 upon the addition of 3 ml. TEL per gallon. In this connection, the yields shown in Table 2 were obtained on an aged catalyst.

With regard to physical stability, no particular problem is anticipated with

TABLE 1—PROPERTIES OF CHARGE STOCKS USED IN 50-BBL. PER DAY T.C.R. REFORMING RUNS IN TABLE 2

	Tibu-Petrolea (Colombia) paraffinic naphtha	Mixed Texas naphthas	Depentanized West Texas naphtha	California (Wilmington) naphtha	California naphtha blend*
Gravity, °A.P.I.	54.6	56.8	57.6	45.9	46.3
Norwood bromine No.	0.9	3.0	1.7	1.0	36.7
Olefins, per cent by volume	0.7	2.2	1.1	0.8	30.3
Aromatics, per cent by volume	11.3	8.8	15.9	16.0	14.7
Sulfur, per cent by weight	0.032	0.084	0.17	0.15	0.59
F-1 Octane Numbers:					
Without TEL addition	33.0	50.8	61.2	55.0	65.2
With addition of 3 ml. TEL per gal.	60.6	68.4	75.2	71.5	75.4
A.S.T.M. distillation, in °F.:					
Initial boiling point	177	128	166	166	225
10 per cent point	265	198	189	264	266
50 per cent point	298	268	212	338	314
90 per cent point	337	338	257	380	368
End point	380	384	295	401	400

*54 per cent straightrun naphtha and 46 per cent coker naphtha from Wilmington crude.

TABLE 2—TYPICAL YIELDS ON T.C.R. REFORMING OF VARIOUS STOCKS IN 50-BBL. PER DAY PILOT PLANT

Charge stock—	Tibu-Petrolea naphtha	Mixed Texas naphthas	West Texas naphtha	California S.R. naphtha	California S.R. and coker blend
Reforming conditions:					
Pressure, psig.	175	175	175	175	175
Space velocity, volumes of naphtha per hour per volume of catalyst in reactor	0.88	0.72	0.70	0.50	0.80
Average reactor temp., °F.	986	982	969	985	955
Recycle gas to naphtha, mol ratio	6.0	9.4	6.4	9.0	5.9
Hydrogen in recycle gas, mol per cent	50	60	67	49	50
Recycle-gas furnace outlet, °F.	1,090	1,070	1,070	1,050	987
Naphtha-furnace outlet, °F.	1,030	1,019	1,013	1,050	987
Yields based on charge:					
10-lb. R.v.p. reformate, per cent by vol.	82.0	87.2	96.1	85.4	94.0
Outside C_4 required, per cent by vol.	—1.0	0.6	6.4	2.7	6.1
C_4+ reformate, per cent by volume	83.0	86.6	89.7	82.7	87.9
Total C_5, per cent by volume	8.6	7.9	4.6	4.8	3.6
Total C_6, per cent by volume	8.4	7.5	3.9	6.5	4.7
C_3 and lighter, per cent by weight	16.1	12.1	8.6	14.5	10.0
Coke, per cent by weight	0.7	0.3	0.2	1.5	1.4
H_2 production, cu. ft. per bbl.	376	414	365	430	247
Properties of C_4+ reformate:					
Gravity, °A.P.I.	53.2	55.4	55.4	44.4	46.6
Norwood bromine No.	9.5	9.8	8.2	17.4	13.5
Aromatics, per cent by volume	44.0	34.6	35.6	45.5	33.1
Sulfur, per cent by weight	0.007		0.010	0.013	0.015
F-1 Oct. Nos. on 10-lb. R.v.p. reformate:					
Without TEL addition	91.1	87.0	85.4	94.9	89.3
With addition of 3 ml. TEL per gal.	99.1	97.1	96.5	101.4	97.9

this catalyst in commercial operation.

Hydrogen enrichment . . . Operations with hydrogen enrichment of the recycle gas showed no measurable advantage. Consequently it is not planned to provide for hydrogen enrichment in the commercial design.

Polymer removal . . . On most reformed stocks it is necessary to provide for the removal of about 1 per cent polymer in order to insure a satisfactory gum test on the motor-gasoline product. This can be accomplished either in a separate rerun tower, into which the stabilizer bottoms are flashed, or by the employment of a "knockout" pot in which a polymer cut can be taken ahead of the primary condenser. The knockout-pot system was tested successfully in the 50-bbl. per day unit. The polymer consists almost entirely of aromatics which boil in the range of 400° to 700° F.

Aviation-gasoline base stock . . . Although the foregoing summary deals entirely with reforming for motor-gasoline production, the process is, of course, equally adaptable for the production of highly aromatic aviation-gasoline base stocks. The preferred charge stocks for such operation are the straightrun gasoline fractions which boil in the 200° to 300° F. range, particularly those which contain substantial amounts of naphthenes from which light aromatics are formed. Naphthenic crudes are obviously a better source of such naphthas than paraffinic crudes.

TABLE 3—T.C.R. REFORMING FOR AVIATION-GASOLINE BLENDING

Charge stock—	West Texas straightrun naphtha	California straightrun naphtha
Gravity, °A.P.I.	54.1	54.7
Boiling range, °F.	212 to 299	202 to 312
F-1 octane number, unleaded	60	68
Reforming conditions:		
Pressure, psig.	175	175
Space velocity, volumes of naphtha per hour per volume of catalyst in the reactor	0.35	0.35
Average reactor temperature, °F.	973	1,023
Gas-recycle ratio	12	12
Yields:		
Preaviation cut (C_4 to 200 °F. end point), per cent by volume	35.2	29.7
Aviation-blend stock (200° to 300° F.), per cent by volume	42.3	32.4
Postaviation cut (300° F. end point plus), per cent by volume	5.0	6.6
C_3 and lighter, per cent by weight	15.0	24.9
Coke, per cent by weight	0.4	2.0
7-lb. R.v.p. aviation stock:*		
Yield, per cent by volume of charge	63.0	48.4
Aviation-blending octane number (F-3) with addition of 4.6 ml. TEL per gal.	99.5	98
Supercharge index number (F-4) with addition of 4.6 ml. TEL per gal.	160	177

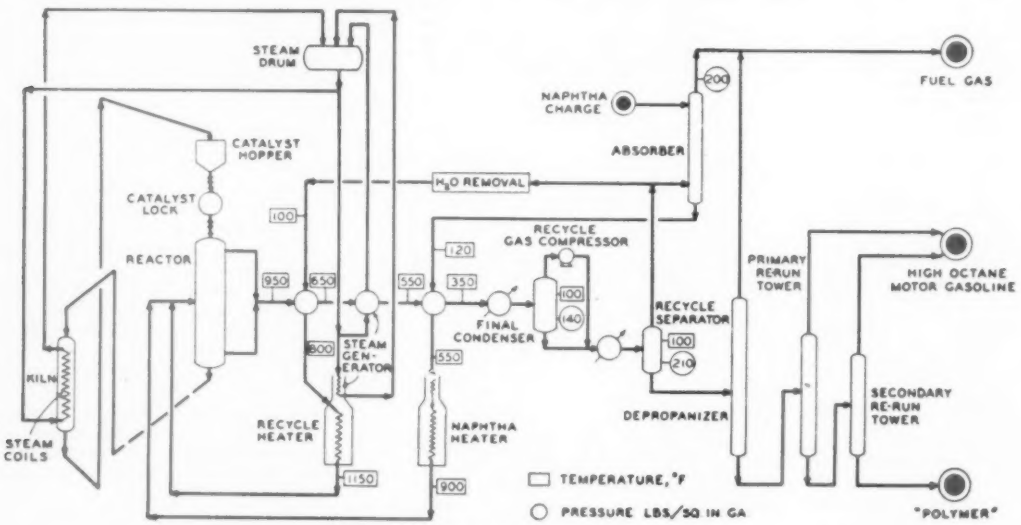
*Pressured with isopentane.

The reforming conditions required for the processing of such stocks for aviation gasoline are somewhat more severe than those necessary for motor-gasoline operation. In a unit designed for motor-gasoline reforming the added severity can be obtained by operation at the maximum temperature and at a somewhat reduced throughput rate—all other conditions remaining constant.

Several reforming runs of this type have been made on representative stocks in the 50-bbl. per day unit. Data on West Texas and Wilmington naphthas are shown in Table 3. Aviation reforming operations can be used equally well to produce reformates rich in specific aromatics such as benzene, toluene, and xylenes.

Commercial Units

Extensive process design and economic studies based on the pilot-plant program demonstrated that the optimum operating conditions are largely independent of feed-stock properties. The final result of these studies led to the selection of a single reactor, without reheat, which employs gas recycle in the amount of approximately 6 mols of recycle gas per mol of naph-



Diagrammatic flow sheet, T.C.R. process—Fig. 2.

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tha, with operation at a pressure of about 175 psig. and at a space velocity of 0.7. Average reactor temperature may range up to 1,000° F. for reforming to an F-1 octane number of 100 upon the addition of 3 ml. TEL per gallon.

Flow plan . . . A schematic flow diagram for a commercial T.C.R. unit is illustrated in Fig. 2. Starting with the reactor, the effluent therefrom flows through heat exchange, with recycle gas and naphtha, to a final condenser. The condensate and gas are then separated in a receiver which operates approximately at a pressure of 140 psig. and a temperature of 100° F. The gas from this receiver is compressed to approximately 210 psig. by the recycle-gas compressor. The condensate is pumped up to the same pressure, after which both are recontacted and cooled before they flow to the recycle separator. The condensate from the recycle separator is pumped to a depropanizer or to other suitable stabilization facilities.

The net gas production flows to an absorber, and thence to the fuel line. Naphtha charge is pumped over the absorber, in order to obtain the desired recovery of light hydrocarbons from this gas; and it is pumped from the base of this absorber through heat exchange, thence through the naphtha heater which raises the temperature to approximately 900° F., and finally into the reactor.

The recycle gas, which is the main stream to leave the recycle separator, passes first through a dryer, next through heat exchange with the reactor effluent, and finally through the recycle heater which heats this material to a temperature of approximately 1,150° to 1,200° F. The hot recycle gas mixes with the heated naphtha just before both enter the reactor.

Catalyst flows downward through the reactor in a compact moving bed. Inasmuch as the catalyst flow is comparatively small, ranging from approximately 5 to 50 tons per hour for units which have throughputs up to 20,000 bbl. per stream day, it may be transported from the base of the reactor to the top of the regenerator with bucket elevators or with other suitable lift equipment. The regenerator is a conventional multizone type of Thermofor kiln, similar in operating principle to those installed on T.C.C. units. This type of kiln is well suited to the low catalyst-circulation requirements of the T.C.R. process, and it does not embody any new or unusual design features.

Catalytic section . . . This part of T.C.R. units is very similar in general arrangement to the catalytic section of the smaller-size bucket-elevator type T.C.C. units, a number of which have been built in the 3,000 to 5,000-bbl. per day range. Just as in these T.C.C. units, the T.C.R. catalytic section is arranged with the reactor and kiln side by side. Auxiliaries to the reactor-kiln system include a hot catalyst storage bin for holding the catalyst during a shutdown, a fresh-catalyst bin, and an elutriator for removing fines from a continuous catalyst slip stream.

The T.C.R. kiln operates at substantially atmospheric pressure. A kiln for a 15,000-bbl. per day T.C.R. unit would normally be designed to burn about 2,000 lb. of coke per hour, with a cat-

TABLE 4—GASOLINE BLENDS FOR 30,000-BBL. PER DAY MID-CONTINENT REFINERY

	T.C.R.		Thermal reforming	
Gasoline component—	Bbl. per calendar day	F-1 Oct. No.*	Bbl. per calendar day	F-1 Oct. No.*
225° F. end point straightrun gasoline			3,296	89.0
280° F. end point straightrun gasoline	5,459	84.6		
T.C.C. gasoline	6,362	98.0	6,362	98.0
Catalytic polymer gasoline	984	106.0	1,310	106.0
Coker gasoline	814	77.5	814	77.5
T.C.R. gasoline	2,978	98.3		
Thermally reformed gasoline			4,198	87.5
Total	16,597	93.1	15,980	93.0
TEL addition for 92.0 F-1 octane-number motor gasoline, ml. per gal.		2.2		2.2

*Upon addition of 3 ml. TEL per gallon.

TABLE 5—PRODUCT DISTRIBUTION FOR 30,000-BBL. PER DAY MID-CONTINENT REFINERY

	T.C.C.		Thermal reforming	
Product—	Per cent by volume	Bbl. per calendar day	Per cent by volume	Bbl. per calendar day
Motor gasoline	55.3	16,597	53.3	15,980
Kerosine	14.1	4,230	14.1	4,230
No. 2 fuel oil	18.9	5,676	18.9	5,676
No. 6 fuel oil—sales	2.5	733	3.7	1,101
Coke, tons		(141)		(141)
Total sales	90.8	27,236	90.0	26,987
Refinery fuel gas	7.0	2,096	7.9	2,387
Refinery fuel oil	0.5	150		
Loss	1.7	518	2.1	626
Total	100.0	30,000	100.0	30,000

TABLE 6—ECONOMICS FOR 30,000-BBL. PER DAY MID-CONTINENT REFINERY

		B.P.C.D.		Incremental	
Production value—	Price (dollars per bbl.)	T.C.R.	Thermal reforming	Bbl. per calendar day	Dollars per calendar day
92 research octane-number motor gasoline	5.04	16,597	15,980	617	3,110
No. 6 fuel oil—sales	1.75	733	1,101	(368)	(644)
Refinery fuel	1.75	2,246	2,387	(141)	(247)
Loss		518	626	(108)	
					2,219

	Dollars per calendar day		
Costs—incremental—	T.C.R.	Thermal reforming	Incremental
TEL (total gasoline)	3,528	3,397	131
Labor and burden	260	180	80
Maintenance and shops	460	267	193
Fuel (includes steam and water)	466	713	(247)
Power	71	103	(32)
Chemical and catalyst	56	54	2
Laboratory	15	10	5
Supplies and miscellaneous	5	2	3
Taxes and insurance	78	53	25
			160
Earnings: T.C.R. over thermal reforming and catalytic polymerization			2,059
Investment—incremental			$1,040,000
Payout, years			1.4

Note: Figures in parentheses are negative.

alyst circulation of approximately 25 tons per hour. Regeneration is accomplished in several burning stages, with cooling between stages. Inasmuch as T.C.R. catalyst burns quite rapidly, the average regeneration temperature is maintained in the range of 800° to 1,000° F., which is approximately 200° F. lower than the comparable temperature in a T.C.C. kiln.

Control of burning is accomplished mainly by regulation of the combustion-air temperature to the various zones. Secondary control is provided by regulation of the cooling coils between burning zones. Just as in T.C.C. units, the cooling coils also serve for steam generation.

The reactor for a 15,000-bbl. per day T.C.R. unit is approximately 11 ft. in diameter, and it is designed to operate at a pressure of 175 psig. The naphtha and recycle-gas feed enter the center of the reactor and flow upward and downward to suitable vapor-disengaging sections. The two vapor streams which leave the reactor are combined before they enter the heat-exchange system.

The commercial reactor is provided with the same type of pressure-lock system as is used for the introduction of catalyst in the 50-bbl. per day unit. The operations of filling, pressuring, emptying, and depressuring are controlled by a cycle timer which operates on a 10-minute cycle. The valves are 8-in. plug cocks which are equipped with stellited plugs and seats with special lubrication grooving; they are of the same design as those used in the 50-bbl. per day unit.

Spent catalyst is purged in the bottom of the reactor; and, after it has left the reactor, it is transferred to a bucket elevator. In Fig. 2 this transfer system is purposely shown in diagrammatic form for the reason that alternate designs are under consideration and because no specific information can be given at this time.

Heat recovery . . . Inasmuch as the heat content of the reactor effluent is large, an efficient heat-exchange system is essential to the economical functioning of the process. Fortunately the reactor effluent material is very stable, and it is possible to heat exchange this stream directly without quenching. This insures the maximum availability of high-temperature-level heat to the extent that approximately 60 per cent of the total heat removed from the reactor effluent serves to preheat the reactor input materials, and an additional 10 per cent is to generate steam.

In the design of the heat-exchange system, particular attention must be paid to the economics of pressure drop, because any pressure drop in the reactor effluent or in the recycle exchanger must be supplied by the recycle-gas compressor.

Fired heaters . . . To avoid thermal cracking in the naphtha heater, the outlet temperature is limited to 900° F. maximum, and the furnace is designed for a high heat input rate to the tubes near the outlet in order to reduce time temperature effects.

Although the recycle gas contains about 1 per cent of pentane and heavier hydrocarbons, it is estimated that no significant cracking of this material will occur at temperatures below 1,200° F. Nevertheless, as an extra precaution, the recycle-gas heater is designed to minimize cracking. In addition, this heater is designed for a low pressure drop, viz., 15 psi. in order to maintain compression requirements at a minimum.

Inasmuch as the recycle gas enters this heater at a comparatively high temperature (approximately 800° F.), only radiant surface is used. For heat economy, the convection section of this heater is designed as a steam-generating unit and is tied in with the same steam drum which serves the kiln. The combination of features maintains the amount of surface required for heating the recycle gas to a minimum, and thus makes it possible to achieve a low pressure drop while thermal cracking effects are reduced to a minimum. The total heat absorbed by the recycle gas and naphtha in the heat-exchange system exceeds that adsorbed in the furnaces by about 20 per cent.

Compression . . . The total pressure drop through a T.C.R. system which operates at a pressure of 175 psig. reactor pressure is approximately 70 psi. For this condition, typical pressures at several points in the system are as follows: recycle-gas compressor, 210 psig.; reactor inlet, 185 psig.; reactor outlet, 175 psig.; and recycle-gas compression suction, 140 psig. Because the recycle gas is circulated in large quantities, and because it has a low molecular weight, this system offers an ideal application for a centrifugal gas compressor. It is proposed, therefore, in plants with a capacity of 2,000 bbl. per stream day, or higher, to install a single centrifugal recycle-gas compressor which will be driven by a condensing turbine.

Absorption and stabilization . . . The product stabilizer is essentially a depropanizer, from which C_4+ reformate is withdrawn as bottoms. Normally the overhead from this unit would flow to fuel gas—although, if desired, some condensate could be recovered therefrom as liquefied petroleum gas (L.P.G.).

The absorber operates at a pressure of 200 psig., and it is designed to recover substantially all of the pentane and heavier components and about 90 per cent of the butanes from the "off" gas. Although this recovery arrangement necessitates the recycling of a small amount of C_4+ material back through the reaction system, it has been established that this design is more economical than an independent absorption and stripping system.

Polymer removal . . . On some light stocks, the stabilizer bottoms can be used for motor-gasoline blending without further processing other than caustic washing. However, when naphthas of 400° F. end point, or higher, are charged, or when naphthas which contain substantial percentages of cracked materials are charged, it is anticipated that the gasoline will contain about 1 per cent of polymer which should be separated.

To accomplish separation with a minimum loss of gasoline, it is proposed to provide a two-stage gasoline rerunning system. The first stage will flash overhead a substantial percentage of gasoline which contains no polymer; the second stage will make a sharp separation between polymer and gasoline of the desired end point.

In the event it becomes necessary to produce aviation blending stocks, the two-tower arrangement will be satisfactory for the preparation of a sharply fractionated high-quality aromatic aviation blending stock. Reboiler heat for these operations may be supplied with fired reboilers or, alternatively, with a recirculating hot-oil system.

An alternate method of polymer removal—one which proved satisfactory in the 50-bbl. per day pilot plant—involves the use of a polymer knockout tower immediately ahead of the final condenser. This tower is operated at just below the dew point of the system, which is approximately 300° F. Gasoline from the recycle separator is used for tower reflux so as to control the heat balance and the amount of polymer removal.

Water removal . . . The 50-bbl. per day pilot-plant studies emphasized the need for dehydrating the recycle-gas stream. An investigation of various drying methods showed that satisfactory drying can be obtained by means of refrigeration, solid desiccant, or liquid desiccant. Although solid desiccant is the most effective for the reduction of moisture content to extremely low levels, the

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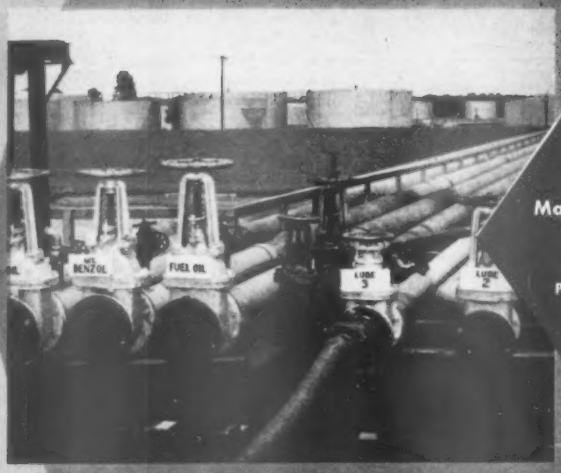

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liquid-desiccant scheme is adequate for this application.

Economics

Numerous factors are important in an appraisal of the economics of catalytic reforming. It does not matter whether a catalytic reformer is installed in an old or a new refinery; to give optimum economic results, it must be properly integrated with other process facilities. Similarly, the properties of the crude oil processed and the octane-number target have an important bearing on the economics for a particular installation.

For purposes of illustration in the present case, a typical medium-sized modern refinery for the processing of 30,000 bbl. per day of Mid-Continent pipe-line crude is used as a basis for comparing economics of installing thermal vs. catalytic reforming equipment.

It is assumed that existing distillation, catalytic cracking, delayed coking, and catalytic polymerization facilities are adequate for the production of present gasoline octane-number requirements, but that reforming is necessary to provide an F-1 92 pool octane number in order to meet future competition. With this pool octane number, it will be possible to maintain a reasonable balance between the production of 95+ octane-number premium-grade, as well as lower-octane-number house-brand, gasolines.

The catalytic reforming and gasoline-blending calculations are based on the use of a T.C.R. unit to reform 3,600 bbl. per stream day of 260° to 410° F. boiling-range (41.4 F-1 unleaded; 64.2 F-1 upon the addition of 3 ml. TEL per gallon) virgin naphtha for the production of a reformate with an F-1 octane number of 98 upon the addition of 3 ml. TEL per gallon. Reformer charge stock is prepared on the crude distillation unit while a 280° F. end-point straightrun gasoline with an F-1 octane number of 84.6, upon the addition of 3 ml. TEL per gallon, is taken overhead.

For comparison, it has been determined that a 5,700-bbl. per stream day thermal reforming unit would be required for the same target octane number. In this case a 5,500-bbl. per stream day naphtha refractionator would be required to provide a 200° to 380° F. boiling-range naphtha charge for thermal reforming—leaving a 225° F. end-point light straightrun gasoline for blending. It is advantageous in this case to expand an existing 1,000-bbl. per stream day catalytic polymerization unit to 1,300 bbl. per stream day (catalytic polymer gasoline) in order to utilize butylenes and propylenes produced from expanded thermal reforming.

The cost of the projected T.C.R. facilities—including a 3,600-bbl. per stream day T.C.R. unit, paid-up royalty therefor, and all off-site requirements—is estimated to be approximately $3,100,000. On the other hand, the cost of equipment for the thermal reforming case—including a new 5,700-bbl. per stream day thermal reforming unit, a naphtha refractionator, additional catalytic polymerization capacity, as well as the paid-up royalty therefor, and associated off-site equipment—is estimated at $2,060,000. Gasoline blends and product distributions for the alternate plans are presented in Tables 4 and 5.

The evaluation shown in Table 6 indicates, for this particular situation, net earnings for the T.C.R. installation—over and above those of the thermal reforming and catalytic polymerization—of approximately $2,000 per day. On the basis of an incremental investment of $1,040,000, a payout of 1.4 years is indicated.

If it were assumed, in this refinery, that thermal cracking facilities were available for reactivation and conversion into a thermal reformer of the

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required capacity, then it might be possible to decrease the investment requirement for the thermal reforming case by approximately 50 per cent. In this case the differential investment would be $2,070,000, and the payout approximately 2.75 years.

Some interesting conclusions can be drawn from the data presented in Tables 5 and 6, which reflect the use of a 3,600-bbl. per stream day T.C.R. unit vs. a 5,700-bbl. per stream day thermal reformer, plus naphtha refractionation and incremental catalytic polymerization, to reach target octane number:

1. Gasoline yield is increased almost 4 per cent for the same octane number by the use of T.C.R. This additional gasoline is produced at the expense of heavy fuel, fuel gas, and volumetric loss.

2. In the case of a refinery which produces light products only, fuel-gas production may be excessive when intensive thermal reforming is employed to reach a high antiknock quality target. Unless L.P.G. or petrochemical utilization is considered, this excess gas would ordinarily be flared—particularly during summer months, when low vapor-pressure gasoline is made. This uneconomic situation may be avoided by the use of catalytic reforming which, in effect, converts fuel gas and loss to high-quality gasoline.

3. Total fuel requirements, including steam and water, are approximately 50 per cent higher for thermal reforming than for T.C.R. Power requirements are 40 per cent higher.

4. Chemical and catalyst costs are almost identical for the two processes. Incremental catalytic polymerization with thermal reforming has a moderate catalyst requirement which offsets T.C.R. catalyst cost.

Although the preceding economics are valid for a refinery situation which requires the manufacture of a comparatively low proportion of F-1 95+ octane-number premium-grade gasoline, some attention should be given to the facilities required for the production of 35 to 45 per cent high-quality premium gasoline in terms of total motor gasoline. In this case it is generally not possible to meet over-all quality requirements by intensive thermal reforming plus catalytic polymerization, and the refiner must turn to catalytic reforming. Economic justification of catalytic reforming in such a situation may be established by considering the losses in revenue incurred by failure to install catalytic reforming facilities. These losses may include those associated with limited or no production of premium-grade gasoline or distress sales of excess straightrun naphtha at low prices.

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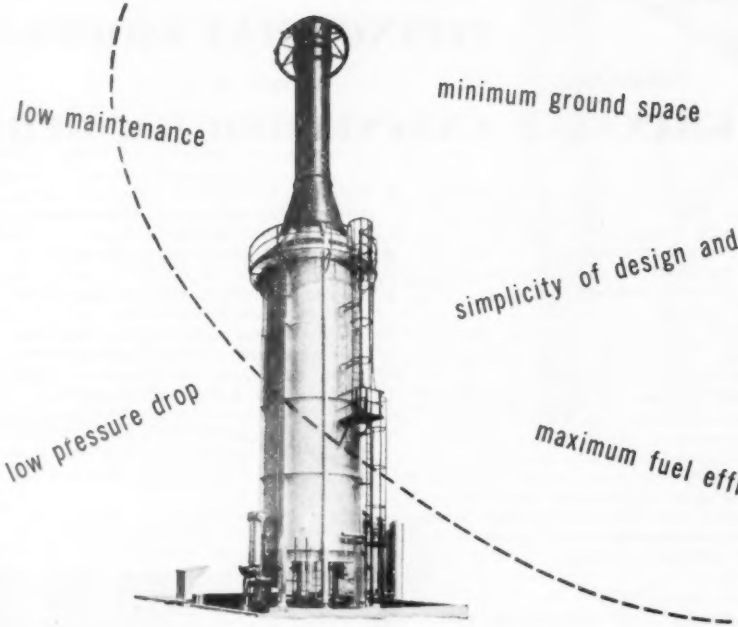

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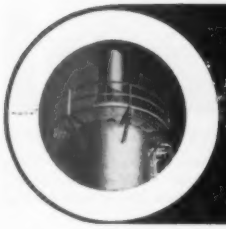

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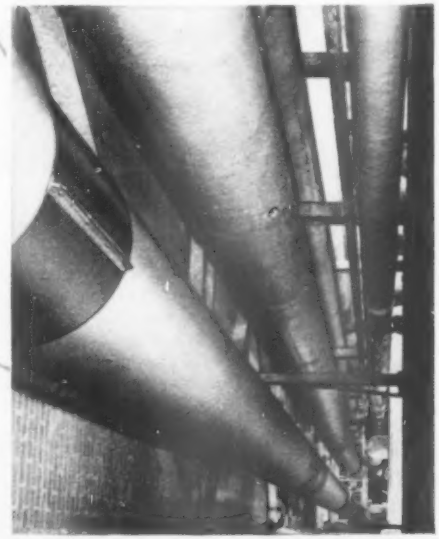

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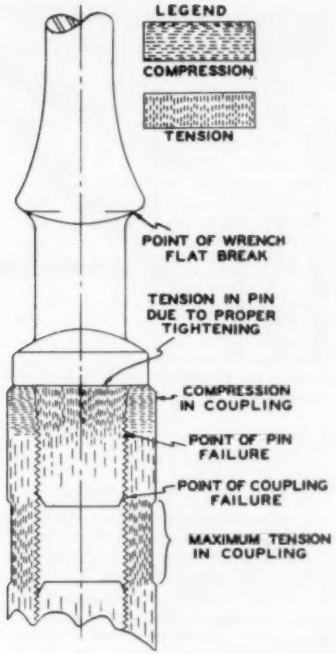
How to Prevent Failures In Sucker-Rod Joints

Here's a seven-point program for reducing joint failures in sucker rods. Check points mentioned against your own practice.

by A. A. Hardy*

WEAR DURING USE is one of the major causes of failure in a sucker-rod joint, Fig. 1, at left.



ANALYSIS OF FORCES in the A.P.I. sucker-rod joint, Fig. 2, at right.

JOINT failures in sucker rods can be greatly reduced, if proper attention is given these points:

1. Controlled tightening of the sucker-rod joint is of paramount importance. Controlled torque wrenching should be used.

2. Tightening too little is far more dangerous than tightening too much.

3. New strings of rods should always be bucked up twice when run for the first time.

4. The stress in the pin in a properly tightened joint is dependent on the cross-sectional area of the coupling. To avoid broken pins the coupling wall should be as thick as practically possible.

5. Hammering a hardened and ground coupling will crack the case and is extremely likely to cause coupling breakage.

6. If coupling breakage is not caused by hammering, the break then starts from the inside as a fatigue break. Rounded roots of coupling threads, heavier wall couplings, and controlling internal coupling corrosion are procedures for eliminating coupling breakage from this cause.

7. The undercut pin design gives promise of eliminating joint failures both in the pin and in the coupling. The neck length should ideally be at least two diameters. The longer the neck, the less is the chance of loosening.

Classes of Failures

All joint failures fall in one of four classes:

1. Completely unscrewing in service.
2. Wear as illustrated in Fig. 1.
3. Failure due to workmanship or material defects.
4. Fatigue of metal, usually accelerated by corrosion.

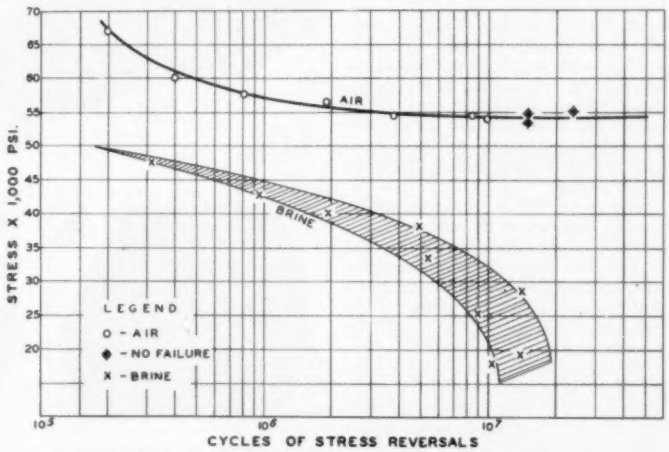
The first two suggest their own remedy. The third, fortunately, is extremely rare; and it, too, suggests its own remedy.

*W. C. Norris Mfg., Inc., Tulsa. Presented at Mid-Continent district meeting, A.P.I. Division of Production, Wichita, 1952.

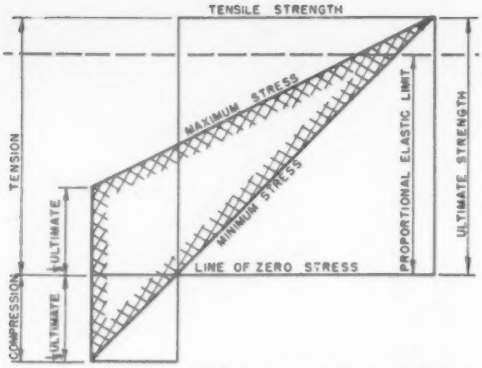
In the hundreds of joint failures examined by the writer, no breaks in the pin proper or in the coupling have been found which are definitely chargeable to original defects with the exception of one pin failure where the coupling face was 0.017 in. out of parallel with the pin shoulder face. A few pin ends broken in the wrench square as indicated by an arrow in Fig. 2 have been inspected. All such are definitely caused by forging defects.

The fourth class, or the break due to fatigue failure, represents about 90 per cent of the source of trouble and is, of course, the hardest of the lot to understand or combat. The nature and cause of fatigue failures are not within the scope of this article. Comprehensive literature on the subject is available. We can simply say that the endurance life of a metal part subject to fatigue can be improved by:

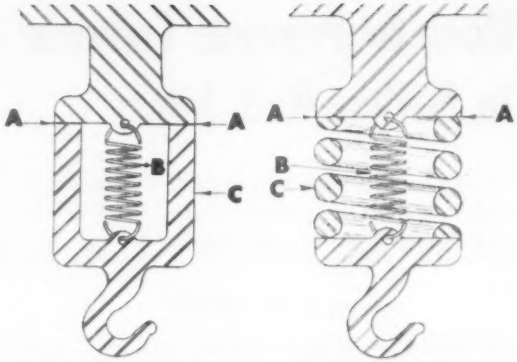
1. Lower the stress as by increasing



FATIGUE TEST of A.I.S.I.-4815 steel in air and in brine. Fig. 3.



GOODMAN DIAGRAM which demonstrates the ranges of stress for analysis of the life of a metal part. Fig. 4.



ANALYSIS OF STRESS in sucker-rod joints; incompressible coupling illustrated in Fig. 5 at left; compressible coupling, at right, Fig. 6.

the metal area.

2. Decrease the rate of corrosion as by use of inhibitors.

3. Decrease the range of stress.

4. Eliminate stress raisers such as sharp notches placed at critical points.

Fig. 3 is a graph which shows the relationship between fatigue life, both in air and in brine, and magnitude of stress; and Fig. 4 shows the Goodman diagram[3] which illustrates the effect of range of stress.

Stress in sucker-rod joint . . . These stresses can be most easily comprehended by visualizing a spring-loaded analog as shown diagrammatically in Figs. 5 and 6. Referring to Fig. 5, assume spring "B" to be exerting a pull of 10 lb. in the assembly. There will then be a reacting pressure of 10 lb. at the contact faces "A." If a load of 6 lb. is placed on the hook, pressure at "A" will be reduced to 4 lb., hence the faces must still be in contact.

If the faces are still in contact, there has been no change in length of the spring, and no change in length means no change in stress or pull. Therefore, as long as the load hung on the hook is less than the pull exerted by the spring, there will be no change in stress in the spring. When the load does exceed the spring's initial pull, the faces separate and all the load is carried directly by the spring.

The spring "B" is, of course, analogous to that part of the sucker-rod pin between its shoulder and the last full thread. The body "C" is analogous to the corresponding part of the coupling, and the initial load in spring "B" to the initial load set up in the pin by proper tightening of the joint.

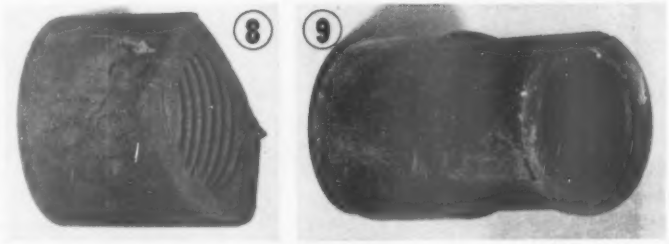
Of course, the coupling wall is compressible, so a more accurate analogy is illustrated in Fig. 6 where the body "C" of Fig. 5 is replaced with a heavy spring "C." Again assume an initial tension of 10 lb. in spring "B." Assume also that it elongates 10 cm. for every pound of load imposed on it. Assume that spring "C," being larger and stiffer, deflects 1 cm. for every pound of load imposed on it.

When 6 lb. is again placed on the hook, the pressure at "A" will again be reduced to 4 lb., and the faces will still be in contact. Spring "C" will elongate 6 cm., being relieved of 6 lb. of its compression, resulting in spring "B" elongating an equal amount.

Six centimeters on spring "B" represents 0.6 lb.; therefore, its tension is increased from 10 lb. to 10.6 lb. by the addition of 6 lb. load. If spring "C" deflected 2 cm. for each pound of load, or twice as far as the first assumption, spring "B" would likewise have double the deflection shown above, or 12 cm., equal to 1.2 lb., with a corresponding resultant load of 11.2 lb. due to the 6-lb. load on the system.

These conditions exist where the body or spring "C" has greater cross-sectional area than the spring "B," or in the case of sucker rods, where the coupling has a greater cross-sectional area than the pin and the pin has a greater cross-sectional area than the rod proper. What happens when these relationships differ is interesting, but beside the point, for good sucker-rod joint design requires this relationship.

Thus, it can be seen that, with proper tightening, the stress added to the pin due to the working load is equal to the reduction in stress which occurs in the coupling due to that working load. Stated another way, assuming an ini-



PIN FAILURE due to fatigue, Fig. 7. **FATIGUE BREAK** due to hammer blow on coupling, Fig. 8. **INSIDE BREAK**, due to fatigue, at point of maximum stress, Fig. 9.

tial stress in the pin great enough so that the faces do not separate, when the string is loaded there is a reduction in the compressive stress in the coupling equal to the load divided by its metal area.

This reduction in stress due to loading is attended with an elongation in the coupling, but as the contact faces do not separate, there must also be an equal elongation of the pin. Equal elongations also represent equal stresses; therefore, the stress added to the **pin** by the working load is numerically equal to the working load divided by the **coupling** metal area, regardless of the pin size.

Following this reasoning, let us investigate the stresses in the two types of joints suggested for use on 7/8-in. rods operated in 2-in. tubing. The first consists of the standard 1 3/16-in. pin with a 1 5/8-in. reduced diameter coupling. The other consists of a 1 1/16-in. diameter pin with a 1 5/8-in. diameter coupling, the A.P.I. standard for 3/4-in. rods. The coupling metal area in the first instance is 0.93287 sq. in.; in the second instance it is 1.15727 sq. in.

Assuming a stress in the pin due to tightening equal to 40,000 psi. and a polished-rod load of 20,000 lb., the maximum stress in the pin in operation in the two cases would be:

For the 1 3/16-in. o.d. pin:

$$S = 40{,}000 + \frac{20{,}000}{.93287} = 61{,}439 \text{ psi.}$$

For the 1 1/16-in. o.d. pin:

$$S = 40{,}000 + \frac{20{,}000}{1.15727} = 57{,}282 \text{ psi.}$$

This difference is not great, but it is significant, surprising as it seems on first thought, that the smaller pin is somewhat stronger in fatigue than the larger pin with the same diameter coupling, at least until the contact faces separate, because of the larger coupling cross-sectional area.

Pin Failures

Practically all pin failures are due to fatigue and invariably occur at the last full thread, as shown by the arrow in Fig. 2. A picture of a broken pin is shown in Fig. 7. The break is always at right angles to the axis of the pin and is smooth and stained in a half moon where the break started and rough and ragged 180° from the start where the final rupture occurred.

The significant fact about fatigue breaks is that they are caused by a high range of stress variation over thousands or even hundreds of thousands of stress cycles and not by high stress alone. No piece of steel has ever been broken by a single high stress even beyond its elastic limit so long as the stress has not exceeded its ultimate strength.

These failures, then, being caused by fatigue must be due to a high range of stress variation. As shown by the stress analysis above, this high range of stress can only occur when the faces separate under load. The faces can only separate when the tension in the pin due to tightening is less than the tension induced due to the working load; or in terms of the analog shown in Fig. 6, when the tension in spring "B" is less than the load applied to the hook.

The remedy, then, obviously is to tighten the joints initially so that the faces do not separate when the working load is applied. This requirement has been pointed out by several authors, such as Mills;[3] Doughtie and Carter;[4] Sauer, Lemmon, and Lynn;[5] Almen,[6] and many others. To do this, a predetermined torque must be carefully applied to the joints as they are run. Doughtie and Carter[4] have suggested a formula showing the relationship between torque and pin stress which appears to work out very well for sucker-rod joints.

$$T = \frac{F}{2}\left(\frac{p}{\pi} + \frac{Ef}{\cos\alpha} + D_c f_c\right)$$

where:

- T = torque required to turn the coupling, lb.-in.
- F = axial tensile load in pin, lb.
- p = pitch of threads, in.
- E = pitch diameter of screw thread, in.
- f = coefficient of friction between threads
- f_c = coefficient of friction between contact faces
- D_c = mean diameter of contact faces
- α = one-half the included thread angle measured in a plane through the bolt axis, = 30°.

Experiments by the writer and a study of similar experiments by others has indicated that the coefficients of friction in this formula should be evaluated at 0.11. This may seem low for the average threaded joint, but the A.P.I. sucker-rod joint is not an average commercial joint. The A.P.I. tolerances make it considerably above average in quality resulting in good finish and lower than average friction.

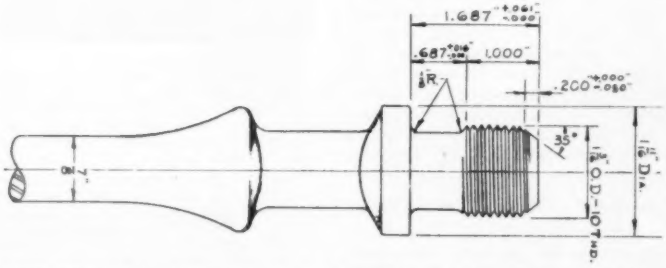
Assuming that the stress desired in the pin is 40,000 psi. and solving for the torque required for this condition, we have the following results:

5/8-in. rods	213 ft.-lb.
3/4-in. rods	340 ft.-lb.
7/8-in. rods	512 ft.-lb.
1-in. rods	770 ft.-lb.

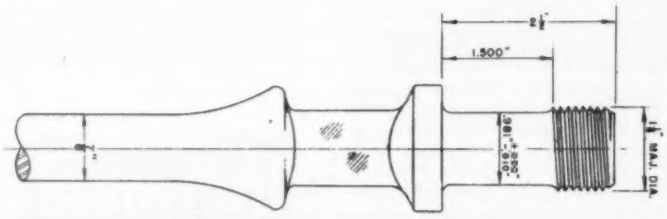
In terms of weight or force required at the end of a 3-ft. arm, this would be:

5/8-in. rods	71 lb.
3/4-in. rods	113 lb.
7/8-in. rods	171 lb.
1-in. rods	257 lb.

It is our experience that an impact wrench, as ordinarily used, will build up between 200 and 500 ft.-lb. of torque, depending on how it is used. If this be true, we should, assuming that the above figures are correct, very seldom experience any breaks in 5/8-in. pins and occasionally experience breaks in 3/4-in. pins. Seven-eighths-inch and 1-in. pins should be the most common



UNDERCUT sucker-rod joint now under test gives evidence of being superior to A.P.I. joint. Fig. 10.



LONG-NECK undercut sucker-rod joint, together with a coupling with rounded thread roots, should drastically reduce joint failures. Fig. 11.

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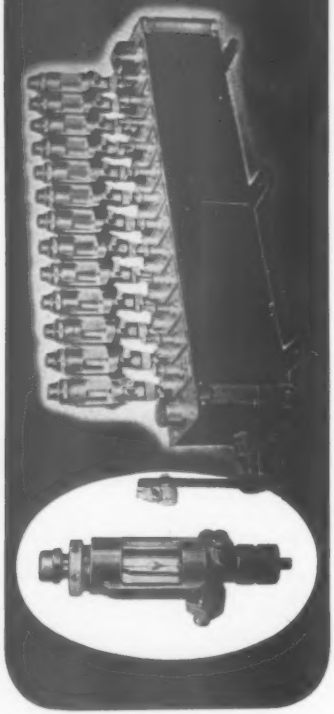

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type of break. This is actually borne out in experience. We never hear of broken ⅝-in. pins. Occasionaly, we have a few ¾-in. broken pins. Most of our pin breaks occur in ⅞-in. rods, with a few 1-in. However, the number of 1-in. rods in operation is far less than the number of ⅞-in. and would explain this discrepancy.

It is our firm belief that we should throw away all of our impact wrenches and use one of the commercially available torque wrenches, air-powered sucker-rod wrenches set for the proper torque, or give the men 2 or 3-ft. cheaters, depending on the rod size, and school them in tightening in the proper manner. The impact wrench method, at the best, is highly uncontrollable and highly unpredictable.

The suggested loading of 40,000 psi. is the minimum that should be used. The danger, as far as failure is concerned, is far less in applying too much torque than in applying too little. D. R. Miller,[7] of the National Bureau of Standards, has pointed out that even if the elastic limit of the pin is exceeded in tightening, no particular harm is done. Actually exceeding it appreciably may be beneficial. One recognized means of improving the fatigue life of steel is to stretch it beyond its elastic limit. This fact has been pointed out by Almen[8] with reference to cut threads on studs and bolts, who also subscribes to torquing threaded connections beyond the yield point where the application is of the same nature as the sucker-rod joint.

Of course, it is conceivable and highly possible that a joint may loosen in service even though properly tightened. This possibility can only be overcome in the present joint by increasing the friction which resists loosening such as by removing all grease on the contact faces of the pin shoulder and coupling, being careful to leave it on the threads of both pin and coupling. This is a large order in actual practice.

Lack of Parallelism of Contact Faces

This subject has caused considerable concern in the industry. Of course, reasonable parallelism should be held, but with the 0.001 to 0.007 in. clearance between the pin and coupling threads allowable under the present standards, together with the plastic flow that occurs in the metal in pin and coupling threads and in the contact faces when properly tightened, the joint will seat itself and will compensate for considerable angularity. For this reason, it would be most excellent practice to fully tighten, then loosen and fully tighten each joint a second time when running a new string of rods.

It is the writer's opinion that a total misalignment of the faces between the

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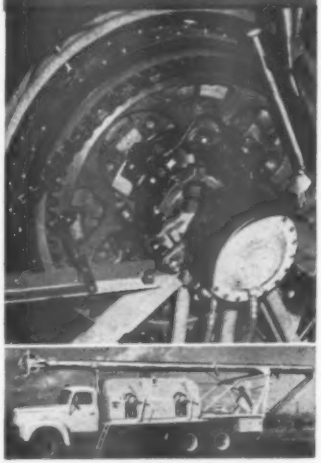

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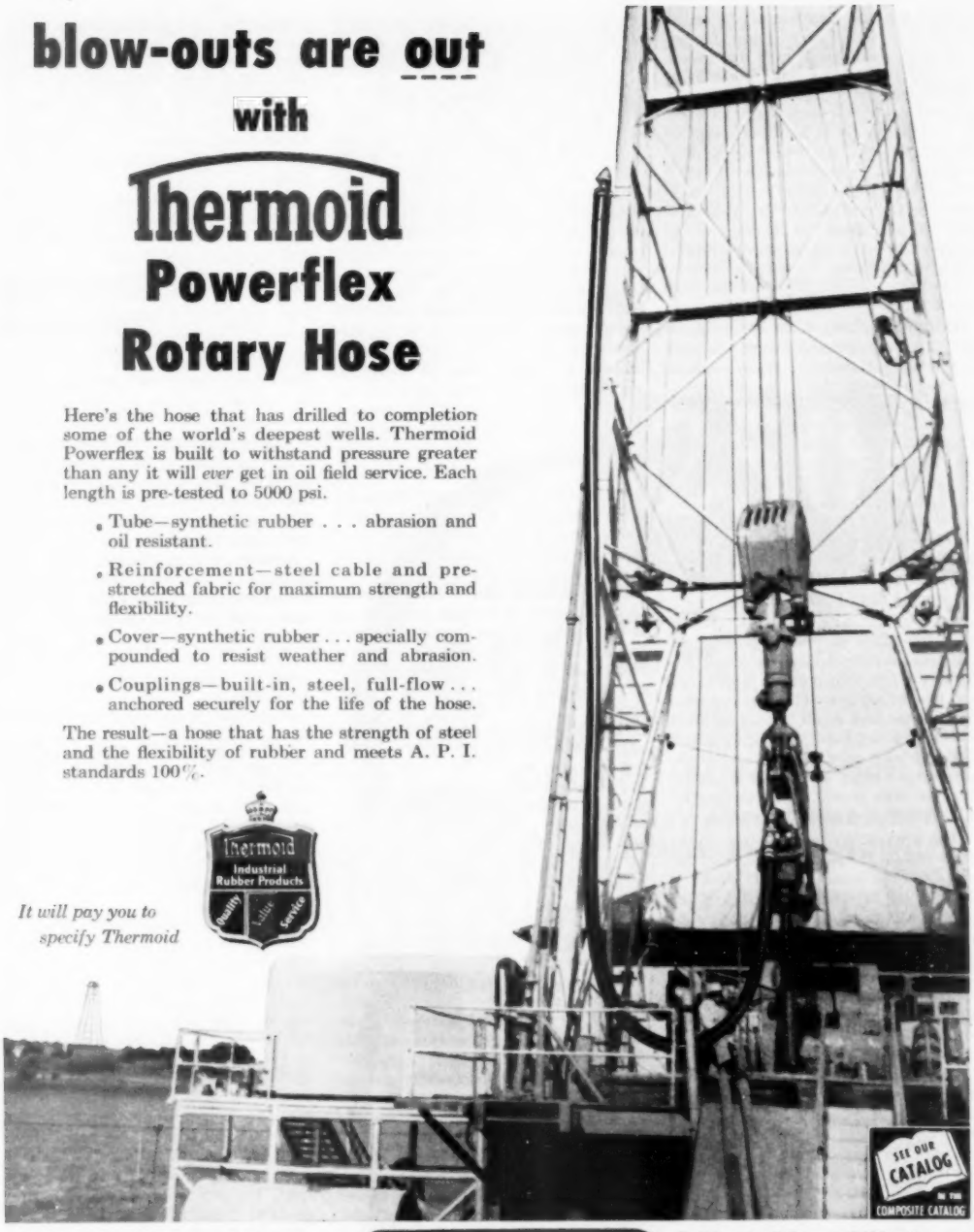

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product pin and coupling of the order of 0.005 in. would do no harm. Larger clearances would cause high stresses on one side of the pin and might even exceed the elastic limit of the metal at some point; but particularly in view of the article by Almen[4] referred to above, this may not be objectionable. It is the cyclic stress and not the high stress that causes failure. It is, however, the writer's opinion that excessive face misalignment is conducive to joints becoming loose in service resulting in pin failures.

Coupling Failures

Coupling failures seem to be peculiar to certain districts, some districts experiencing none while others seem to be plagued with them. In all probability they are associated with crooked-hole country. All couplings fail in fatigue and at the point which coincides with the first thread on the pin as indicated in Fig. 2. The start of this failure, while in the region of the end of the wrench flat, seldom, if ever, coincides with the wrench flat. The writer has never seen a broken coupling whose break could be definitely attributed to the wrench flat.

Another fact which seems to present itself on limited observation is that the couplings usually appear to break opposite the first thread of the bottom pin and not the top pin. The only apparent significance here might be that the fluid which seeps into the joint being corrosive and lying on top of the end of the bottom pin might hasten corrosion fatigue at this point. Confirmation on this thought should be sought.

The start of the fatigue break sometimes lies on the outside surface of the coupling, but usually is in evidence at the root of the threads on the inside. If on the outside, the break can be invariably traced to a crack in the hardened case caused by a hammer blow. Even a moderate blow can crack the case of a hardened and ground coupling, and such cracks are ideal points for fatigue breaks to start. This is illustrated in Fig. 8.

If this condition is suspected, it can be easily proved by etching the broken coupling in a 50 per cent solution of hydrochloric acid at 160° F. for 30 minutes. This procedure will bring out the hammer-blow marks with surprising clarity.

As previously mentioned, however, most of the breaks start from the inside as shown in Fig. 9. This type of break starting from the inside cannot be caused by bending or hammering, either of which would have its maximum effect on the outside surface. It then must be the result of fatigue starting at the point of maximum stress, together with the sharp V-notch effect of the threads at this point. Considered in this light, then, these breaks should start where they do, on the inside and at the end of the pin.

Correcting this condition presents a real problem, for there is no means of limiting the range of stress at this point in the coupling as there is in the pin. Three possible methods do present themselves, however: (1) Increase the metal area at this point, thus reducing the magnitude of the stress. (2) Assuming corrosion to be a contributing factor, use some type of corrosion inhibitor inside the coupling, thus materially increasing the fatigue endurance life as shown by Fig. 3. (3) Treating the thread roots in the coupling in some manner to reduce their V sharpness and consequent fatigue vulnerability. Rounded roots, instead of the present A.P.I. standard flat roots, might be used.

The Undercut Pin

During World War II the aviation industry developed the undercut thread for studs and bolts and thereby practically eliminated fatigue failures in such components which had been disastrously troublesome. The undercut thread consists of turning the body of the threaded member between the last full thread and the seating shoulder to a cylindrical section slightly less in diameter than the minor diameter of the threads.

This principle is not new, having been applied to sucker rods as early as 1932, but it is now universally recognized as the preferred design for threaded components subjected to reversals of stress.

The undercut thread as applied to the sucker-rod joint is covered very ably by D. R. Miller in the article referred to above.[3] It accomplishes two important things:

1. It materially reduces stress concentration at the root of the last full thread and streamlines the stress flow in a manner that greatly reduces fatigue vulnerability.

2. If the cylindrical portion is of an appreciable length, the elongation of this section under initial tightening stress can be very successfully used to offset the slight relaxation of this initial stress which invariably occurs as a result of the plastic flow of the metal or "seating" of the joint under the working load.

In this way the joint stays tight and more nearly maintains its original tightening stress. The longer the cylindrical section, the greater will be the elongation under any given stress and the greater will be the capacity to absorb plastic flow with minimum relaxation.

Fig. 10 illustrates one design of undercut joint which is currently under test and which has given definite evidence of being superior to the A.P.I. joint so far. It can be machined from the present A.P.I. pin forging with the present threading die heads, and uses the present A.P.I. couplings. Fig. 11 shows a preferred design with a longer neck and slightly smaller diameter, but which would require new forging dies, new threading equipment, and new couplings.

To illustrate the desirable effect of the longer neck, let us consider actual figures for the 7⅞-in. joint. Basically, unit elongation equals unit stress divided by the modulus of elasticity; then at 40,000 psi. representing the desired neck stress due to tightening alone:

$$\text{Elongation} = \frac{40{,}000}{29{,}500{,}000}$$

$$= 0.00136 \text{ in. per in.}$$

The distance from the last full thread to the shoulder on the A.P.I. joint is 0.550 in. This is not all free to stretch due to the imperfect threads, but for the purpose here, we shall assume it is. This same distance on the neck of the pin shown in Fig. 10 is 0.687 in. and in Fig. 11 is 1.5 in. The respective elongations under the same tightening stress of 40,000 psi. will then be:

A.P.I.: $0.00136 \times 0.550 = 0.00075$ in.

Fig. 10: $0.00136 \times 0.687 = 0.00093$ in.

Fig. 11: $0.00136 \times 1.500 = 0.00204$ in.

It is conceivable that three-fourths of one-thousandth of an inch relaxation of elongation could occur in "seating" of the A.P.I. joint. If it did occur, the joint would loosen in service and fail very shortly in fatigue. The undercut joint of Fig. 10 is 25 per cent better, but the long neck of Fig. 11 is 172 per cent better.

In the writer's opinion, the long neck joint would always stay tight if properly tightened in the first place, for it is inconceivable that plastic flow of the metal would absorb the 0.002 in. in seating under the working load. The pin outside diameter has been reduced to 1⅛ in. instead of the A.P.I. 1 3/16 in. which enables us to put more metal in the coupling and thus reduce the range of stress in the pin as shown above, as well as increasing the strength of the coupling itself.

It is the writer's opinion that this joint, together with a coupling with rounded thread roots, would go a long way toward eliminating our present joint failures.

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Water-Imbibition Displacement

(Continued from page 265)

vasion front lead one to expect that the time required for invasion would be proportional to the square of the distance invaded. The laboratory data on several plates confirm this.

Laboratory results on rate of water penetration have been adjusted to correspond to reservoir displacement, taking into account the difference in laboratory and reservoir-oil viscosities and the presence of free gas and connate water. The adjusted curve, Fig. 2, shows that in the reservoir water will completely penetrate a matrix block 1 ft. thick within ½ year and even penetrate a block 6 ft. thick within 15 years (3-ft. penetration from two sides). If the reservoir performs as well as the laboratory data indicate, the rates of penetration would be sufficient for economic application to the Spraberry.

Variable results . . . Quantitative data on the displacement efficiency of the imbibition process has been obtained on small plates and on core-plug samples of Spraberry rock which contain interstitial water and which are saturated with oil. These results are variable, ranging from zero to 67 per cent oil recovery. The average value, resulting from 2 to 7 days of imbibition, is 31 per cent. The majority of the recovery occurs within 2 days in the small samples, and this 2-day value is compatible with the rate of imbibition as given by Fig. 2. (These recovery data are shown as a function of core properties in Table 1.)

The value of 31 per cent recovery behind the imbibing front was used together with the rate-of-penetration curve of Fig. 2 to obtain the rate of oil displacement per unit area of contact of fracture and matrix. It may be anticipated that the presence of free gas in the reservoir will tend to increase the oil-displacement efficiency.[7]

Estimating fractures . . . As mentioned previously, the success of a natural-imbibition process of this sort depends upon the presence of a large number of interconnected fractures. The problem of estimating the size and number of fractures in the Spraberry has been one of considerable interest. One company cored a directional well in one section of the Spraberry trend and found native fractures, 3 to 4 ft. apart in the uppermost section of the Spraberry. Sohio Petroleum Co. estimated the average width of the fractures to be 0.002 in. from micrometer measurements on cores.[2]

An estimate of the frequency of occurrence of the fractures may be made by comparing the calculated flow capacity of an individual fracture with the in-place permeability of the reservoir (since the reservoir permeability is due to the presence of the fractures).

The in-place reservoir permeability may be determined by a pressure-build-up-curve analysis.[5] This type of comparison, assuming the fractures are 0.003 in. wide, are vertical, and extend through a pay thickness of 20 ft., gives an average spacing of 3 ft. for the average permeability of 30 md.[1] Assuming that the nature of the fractures remain the same, the fracture spacing in specific areas of the region will be inversely proportional to the permeability of the region. This fracture spacing was used in estimating the matrix surface area available for contact by

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water. If the smaller fracture width reported by Sohio had been used, the calculated surface area available for imbibition would have been substantially greater.

It has been mentioned that there is some indication that the fractures in the Spraberry are oriented, which might lead to irregular movement of water. An analysis of pressure and production data in the Driver area showed some tendency to drain preferentially in a northeast to southwest direction, but this was not great.

Application to field . . . Using the foregoing laboratory data corrected to field conditions, it is possible to make a preliminary estimate of what the field application of this process might do in the upper Spraberry of the Driver area. It appears that the reservoir will imbibe water and displace oil sufficiently rapidly to maintain the production rate in the neighborhood of 100 bbl. of oil per day per well for several years with only moderate water production. Thereafter, water would be expected to be produced at increasing rates. Oil-production rate is arrived at using the estimated fracture spacing to give the total fracture surface in the radius of drainage, estimating the rate of water imbibition into this surface based on the rate of penetration given in Fig. 2, and taking the average oil recovery in the invaded zone as 31 per cent of the oil in place. The ultimate recovery is estimated to be about three times the natural depletion recovery.

Although the results are very encouraging, it should be emphasized that this work is in the purely experimental stage and confirmation in a pilot flood is essential before the process can be considered for field application. Atlantic Refining Co. is conducting a field test of the water-imbibition displacement process on the Schrock 34 lease. Water is to be injected into three wells, and the production behavior of offset and surrounding wells will be followed. Initially, 200 bbl. of water per day will be injected into each of the wells, this rate being adjusted later depending upon the results obtained during the test.

Conclusions

1. Laboratory tests indicate that a water-imbibition process should substantially increase recoveries in the Spraberry.

2. In general, for successful operation, this water-imbibition displacement requires:

(a) That the oil be stored in the matrix.

(b) That the matrix rock be water wet; i.e., imbibe water and release oil.

(c) That the reservoir be highly fractured; i.e., the fractures must be sufficiently close to each other to permit water to imbibe into a substantial fraction of the reservoir in a reasonable length of time.

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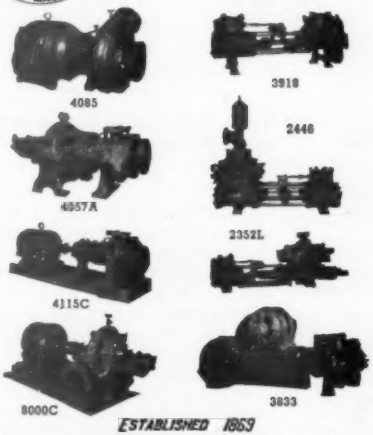

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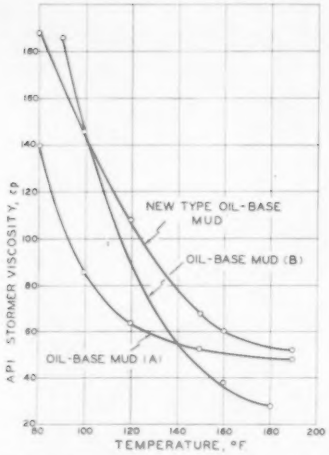

Fig. 1—Temperature vs. viscosity of new type oil-base mud and oil-base muds A and B.

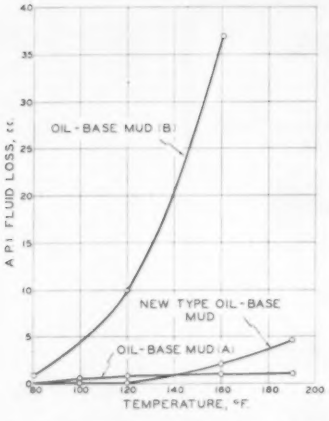

Fig. 2—Temperature vs. fluid loss of new type oil-base mud and oil-base muds A and B.

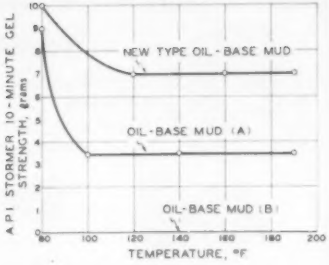

Fig. 3—Temperature vs. 10-minute gel strength of new type oil-base mud and oil-base muds A and B.

New Type Drilling Mud Offers Some Interesting Advantages

Product is easily prepared, maintains excellent viscosity, gel, and fluid-loss properties. Drilling personnel like the nonsticky nature of the mud and ease of after cleaning

by J. L. Lummus* and T. H. Dunn*

A NEW drilling fluid which can be prepared easily from a wide variety of oils, including refined oil, crudes, and topped crudes by addition of a dry concentrate, is now available. It can be mixed easily without heating, its properties are easily controlled, and it is not objectionable to handle. It shows excellent tolerance to the detrimental effects of elevated temperatures and contamination with water, cement, and anhydrite.

Composition . . . The new oil-base mud is prepared in the proportions of 80 lb. of dry concentrate to 0.9 bbl. of oil. This formulation yields a mud weighing 8.5 lb. per gal. Higher-weight muds, up to 15 lb. per bbl., can be prepared by addition of weighting agents. The dry concentrate consists of a chemically treated mixture of clay and weighting material manufactured by a carefully controlled process.

This concentrate is packaged in 100-lb. bags similar to those used for other common drilling-mud clays or weighting materials. The concentrate remains stable and does not become lumpy on prolonged storage.

The concentrate is easily dispersed and mixed with the base oil to form the oil-base mud. A wide variety of oils may be used in preparing this mud; for instance, various crudes of from 18° to 24° A.P.I. gravity, mixtures of topped crude and crude, or mixtures of topped crude and fuel oil.

Effect of Base Oil

Table 1 shows the properties of muds prepared from different types of base oil. The concentrate used in this case was that prepared from a large batch manufactured for a field trial of this mud described later in this paper. In this and the following laboratory tests, a standardized mixing time of 30 minutes was used; however, normally only a few minutes stirring with a high-speed laboratory mixer is necessary.

It will be noted from Table 1 that suitable oil-base muds were prepared from oils obtained from widely varying sources. The results are representative of those obtained with a large number of oils tested in this investigation but not included in this table.

Effect of Temperature

Figs. 1, 2, and 3 illustrate the effect of temperatures up to 190° F. on the physical properties of the mud prepared from Toborg crude (Table 1). Comparative data are shown for two commercially available muds designated as A and B in this paper. It will be noted that the viscosity of the new type oil-base mud over the temperature range from 80° to 190° F. compares favorably with the viscosities of oil-base muds A and B.

From Fig. 2 it will be noted that the fluid loss of the new oil-base mud over the temperature range studied is less than that of oil-base mud B, but is slightly higher than that of oil base mud A in the temperature range from 145° to 190° F. Below this range, values obtained for the new mud are the same or slightly lower than those obtained for oil base mud A. Fig. 3 shows that the Stormer 10-minute gel strength of the new oil-base mud is

TABLE 1—PROPERTIES OF NEW OIL-BASE MUD

Base oil—	A.P.I. gravity, 60° F.	Physical properties, A.P.I. Code 29[1]: Stormer viscosity, cp.	Gel strength, g. Initial	Gel strength, g. 10 Min.	Fluid loss, cc./30 min.
Toborg field crude, Texas	19.5	185	0	7	zero
Sour Lake field crude, Texas	19.6	190	0	5	1.0
Sholem Alechem field crude, Oklahoma	22.8	200	0	7	zero
Wilmington field crude, California	17.0	190	0	4	1.5
70 per cent refinery crude + 30 per cent fuel oil	24.8	200	0	6	zero

*Stanolind Oil & Gas Co., Tulsa. Presented at Rocky Mountain district meeting, A.P.I. Division of Production, Casper, Wyo., 1952.

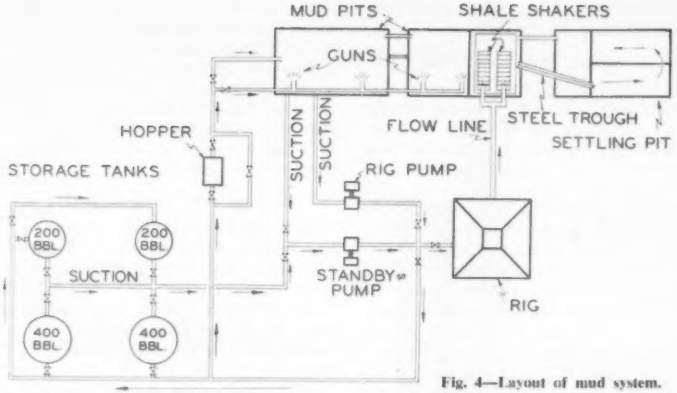

Fig. 4—Layout of mud system.

higher than that obtained for muds A and B.

An investigation was made of the effect of stirring this mud continuously for 16 hours at 20,000 psi. and 350° F. The mud was contaminated with 2 per cent fresh water to more nearly simulate field operations in which oil-base muds usually become contaminated to some extent with water. The results showed that the new type mud was not significantly affected by exposure to the severe operating temperature and pressure conditions.

Effect of Common Contaminants

Table 2 shows the effects of fresh-water contamination on the physical properties of the new mud and two other oil-base muds designated as muds A and C.

Table 2 shows that contamination with as much as 20 per cent fresh water does not significantly affect the fluid loss or gel strength of either the new oil-base mud or mud A, but that it does increase the viscosity of both muds; however, the viscosity of both muds still remains in the pumpable range. The gel strength and viscosity of mud C are both increased; the large increase in 10-minute gel strength (to 33 g.) would be sufficient to require treatment.

Addition of as much as 5 lb. per bbl. of either cement or finely ground anhydrite to the foregoing muds did not significantly affect their physical properties.

Viscosity of this mud can be altered over a considerable range by additions of dry concentrate to increase viscosity and a light oil such as No. 2 fuel oil to reduce viscosity. Such moderate additions of concentrate or light oil do not impair the other desired mud properties; this is illustrated in Table 3.

Field Use

A field test of the new oil-base mud made in a well in Velma field, Oklahoma, while drilling shale and sand sections in the interval from 3,150 to 4,660 ft. showed that this mud mixed easily and maintained excellent properties as a drilling fluid throughout the test. Thus the primary object of the field test was accomplished, even though a severe loss of mud occurred because of over-

TABLE 2—EFFECT OF FRESH WATER CONTAMINATION

Mud—	Per cent water	Physical properties, A.P.I. Code 29			
		Stormer viscosity, cp.	Stormer gel strength, g.		Fluid loss, cc./30 min.
			Initial	10 Min.	
New oil-base mud	None	180	1	7	zero
	10	198	1	7	zero
	20	225	1	7	0.1
Oil-base mud A	None	80	1	4	zero
	5	90	1	7	zero
	10	103	1	7	zero
	20	147	1	7	zero
Oil-base mud C	None	63	1	1	1.0
	5	185	16	16	zero
	10	197	3	22	zero
	20	215	9	33	zero

TABLE 3—VISCOSITY CONTROL OF OIL-BASE MUD

Description—	Physical properties, A.P.I. Code 29			
	Stormer viscosity, cp.	Stormer gel strength, g.		Fluid loss, cc./30 min.
		Initial	10 Min.	
Prepared oil-base mud	185	0	7	zero
Plus 20 lb./bbl. concentrate	225	0	9	zero
Plus 5 per cent by volume No. 2 fuel oil	185	0	6	zero
Plus 10 per cent by volume No. 2 fuel oil	150	0	6	zero

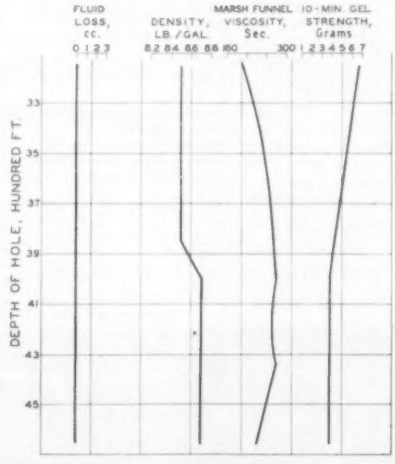

Fig. 5—Properties of new oil-base mud vs. drilling depth on a southern Oklahoma well.

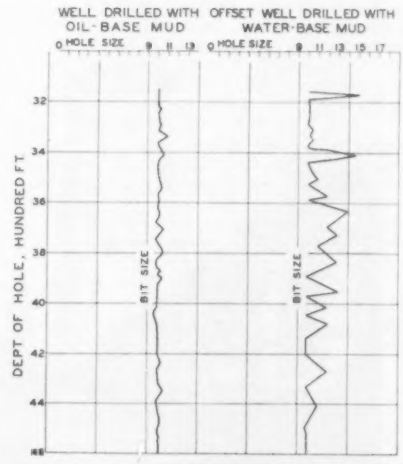

Fig. 6—Comparison of caliper logs over same interval from 3,150 to 4,600 ft. in offset wells.

loading of the shale shakers by a sudden sloughing of a large volume of gelled water-base mud and bit cuttings from enlarged upper portions of the hole that had been drilled with water-base mud.

The cuttings and water-base mud had remained in the hole during the displacement of water-base mud with the oil-base mud. This loss of mud prevented drilling to the objective sand.

Fig. 4 shows the mud system used in this test which, with the exception of the shale shakers, proved to be very satisfactory for handling the oil-base mud. An important feature of this system was its independence of normal rig operations which permitted the oil-base mud to be mixed while normal drilling proceeded and consequently saved rig time.

The storage tanks for the base oil and fuel oil, the conventional hopper-jet mixer, and the steel mud tanks were tied in with the rig standby pump with piping so arranged that efficient transfer of the mud and mud constituents could be accomplished. Two shale shakers were mounted on the middle tank with a collector pan underneath equipped with an outlet to divert flow of the mud through a trough to the settling pit. Additional necessary equipment included a shale shaker bypass, a drip pan for racking the drill pipe, and a boiler to provide steam for heating and cleaning the rig.

Mixing Mud in the Field

In the field test 1,000 bbl. of oil-base mud were prepared by adding 36 tons of concentrate to 810 bbl. of 22.8° A.P.I. gravity crude oil obtained from a nearby field. The procedure was to transfer 200 bbl. of base crude from the storage tank to the steel mud pits through the hopper-jet mixer while adding 9 tons of concentrate. After the concentrate and crude had been mixed, the pump suction was changed and the mixture gunned for approximately ½ hour.

As a final step 25 bbl. of light fuel oil was added slowly and the pits were again gunned for approximately 15 minutes. The dry concentrate did not plug the hopper; it mixed readily, and the mixture was homogeneous when discharged from the hopper into the suction pit. The resulting oil-base mud (250 bbl.) was tested and found to have the following desired properties:

Weight, lb. per gal.	8.5
A.P.I. Stormer viscosity, cp.	200
Marsh funnel viscosity, sec.	210
A.P.I. fluid loss, cc.	0
Stormer initial gel strength, g.	1
Stormer 10-minute gel strength, g.	7

The oil-base mud was then transferred to the storage tanks and the above procedure continued until 1,000 bbl. of oil-base mud was prepared. Approximately 16 hours were required to prepare this quantity of mud. The storage tanks were checked after the mud had been stored for approximately 2 days and it was found that no settling of solids had occurred.

Drilling With Oil-Base Mud

To avoid contamination of the oil-base mud in displacing the fresh-water mud and also to avoid flocculating the fresh-water mud in the hole, fresh water and then salt water were pumped down ahead of the oil-base mud. The changeover required approximately 4½ hours.

Fig. 5 shows that the oil-base mud maintained satisfactory properties for a period of 14 days over a drilling interval of 1,510 ft. It will be noted that the mud maintained a zero fluid loss throughout the test. The filter cake deposited by this mud was less than 1/32 in. thick, and appeared as a grease-like film containing few solids. The mud remained at its original density of 8.5 lb. per gallon during the first 5 days of drilling some 700 ft. of sand and shale. However, as a result of the buildup in the mud of finely ground bit cuttings the density increased gradually to 8.7 lb. per gallon during the next 2 days of

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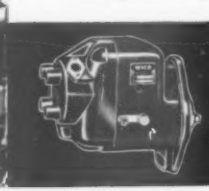

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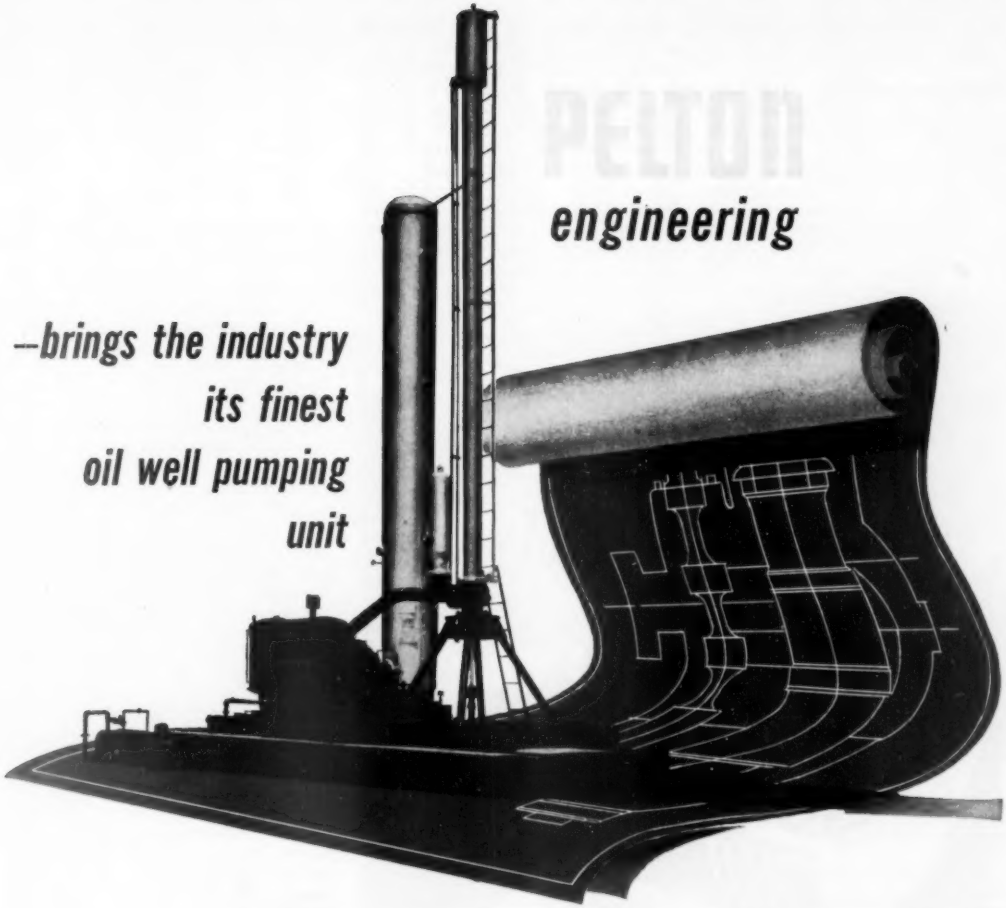
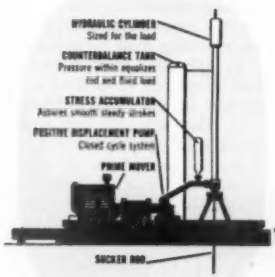


The PELTON Long Stroke Hydraulic Pumping Jack



This outstanding heavy duty pumping unit with stroke lengths up to 30 ft. and polished rod loads up to 40,000 pounds produces more oil per day than any pumping means known.

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drilling and remained at this value to the end of the test.

Viscosity considerations . . . The Marsh-funnel viscosity of the oil-base mud when mixed was 210 seconds per quart. The viscosity increased gradually as drilling progressed and at times was as high as 280 seconds per quart; this was attributed to solids and formation water entrained in the mud and to the loss of light ends from the base crude oil used in initially mixing the mud. This high viscosity was effectively reduced by addition of a light fuel oil.

For example, over a drilling interval from 4,340 to 4,660 ft. approximately 10 per cent oil was added to the mud and this reduced the viscosity from 280 to 240 seconds per quart. It will be noted that the 10-minute gel strength of the mud was 7 g. initially and decreased gradually to 4 g. where it remained to the end of the test.

Shale-shaker operation . . . At a depth of 4,300 ft. there was a sudden sloughing of a large volume of gelled water-base mud, and bit cuttings from upper enlarged hole sections previously drilled with a poor-quality water-base mud. The shale shaker was not of sufficient capacity to handle these solids, and a large proportion of the oil-base mud was lost by physical entrainment with this great volume of solids. However, the remaining oil-base mud maintained good mud properties, and in spite of this trouble, the drilling proceeded in a normal manner, the bit did not ball up, and the hole stayed to gage.

Record comparisons . . . A comparison of the drilling time and bit records of this well and an offset well drilled with water-base muds over approximately the same drilling intervals shows that the use of the oil-base mud did not decrease drilling time nor did it result in any appreciable savings in the number of bits used. However, the bits pulled on this job were in perfect condition with respect to bearing wear and only the tops of the cutter teeth were worn out, which was in contrast to bits pulled on an offset well drilled with water-base mud under comparable conditions.

If additional weight could have been applied, these bits would have undoubtedly drilled more hole. In southern Oklahoma it is difficult to drill through the steeply dipped shale sections without obtaining hole deviations and an increase in the weight on the bit increased this deviation sharply.

Caliper surveys were made to compare hole size obtained with this mud with that obtained with a water-base mud on an offset well. Fig. 6 shows the two logs over the interval from 3,150 to 4,600 ft.

It was realized prior to the field test that oil-base muds are inconvenient to handle and every effort was made to minimize this factor. However, on this well the drilling crews did not find the oil-base mud objectionable to handle; they were pleased with the non-sticky nature of the mud and the ease with which it was cleaned from equipment and clothing.

Conclusions

1. A basically different type of oil-base mud has been developed which is easily mixed and maintained, and exhibits good tolerance to the adverse effects of elevated temperatures and common drilling mud contaminants.

2. The new mud maintained excellent properties in drilling a long shale section in a southern Oklahoma well.

3. The new oil base mud will be particularly applicable for completing wells in formations in which filtrate from water base mud causes clay hydration or serious water blocking in the case of preferentially oil wet formations.

Reference

1. A.P.I. Code No. 29, "Recommended Practice on Standard Field Procedure for Testing Drilling Fluids."

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HOUDRIFORMING . . .

at low pressure

Data are presented which indicate that excellent yield-octane relationships and high octane numbers can be obtained with Houdriforming catalyst in a relatively low-pressure operation.

by J. C. Dart,* A. G. Oblad,* and J. W. Schall*

PILOT-PLANT data show that a typical motor naphtha may be Houdriformed at low pressures to obtain high yields of aromatics and high-octane motor gasoline.

A West Texas sweet mixed-base naphtha has been reformed to produce maximum yields of aromatics and high-octane motor gasoline. The data indicate that all of the naphthenes in the charge stock were converted to aromatics. In addition, substantial amounts of paraffins were aromatized. An extremely favorable yield-octane relationship was obtained.

An F-1 octane-number rating in excess of 98, without TEL addition, was obtained at a 10-lb.-R.v.p. gasoline yield of 90.2 per cent by volume.

*Houdry Laboratories, Houdry Process Corp., Marcus Hook, Pa. Presented at mid-year meeting, A.P.I. Division of Refining, San Francisco, 1952.

Reaction conditions . . . Data are presented which illustrate the results obtained when a commercially available West Texas sweet mixed-base naphtha was processed at an operating pressure of 275 psig. This stock was processed to obtain maximum yields of both aromatics and high-octane-number motor gasoline. The process data were obtained with the use of a single batch of Houdriforming catalyst in continuous operation in a three-reactor adiabatic pilot unit.

Inspections of the West Texas sweet mixed-base naphtha are presented in Table 1. The naphtha contains a total of 41 per cent by volume of naphthenes, including approximately 14 per cent by volume of alkylcyclopentanes. The naphtha was processed at three different conditions of space rate (volume of oil per hour per volume of catalyst) and reactor inlet temperature. An operating pressure of 275 psig. and a recycle-gas-to-oil mol ratio of 5 were maintained in all runs.

TABLE 1—INSPECTIONS OF WEST TEXAS SWEET MIXED-BASE NAPHTHA

Gravity, °A.P.I.	55.4
A.S.T.M. distillation, °F.:	
Initial boiling point	228
5 per cent point	238
10 per cent point	241
20 per cent point	245
30 per cent point	249
40 per cent point	254
50 per cent point	260
60 per cent point	269
70 per cent point	276
80 per cent point	288
90 per cent point	303
95 per cent point	314
End point	332
Recovery, per cent by volume	99.0
Reid vapor pressure at 100° F., lb.	1.0
Sulfur, per cent by weight	0.07
Octane numbers:	
F-1, without TEL addition	48.7
F-1, with addition of 3 ml. TEL per gal.	67.0
F-2, without TEL addition	46.6
F-2, with addition of 3 ml. TEL per gal.	65.1
Chemical composition, per cent by volume:	
Paraffins	46
Olefins	1
Naphthenes	41
Aromatics	12

Data were obtained at a volume space rate of 3.0 and reactor inlet temperatures of 950° and 975° F., and at a volume space rate of 1.5 at a reactor inlet temperature of 975° F. Thus, for these runs, severity was increased at constant space rate by an increase in reactor inlet temperatures, and was

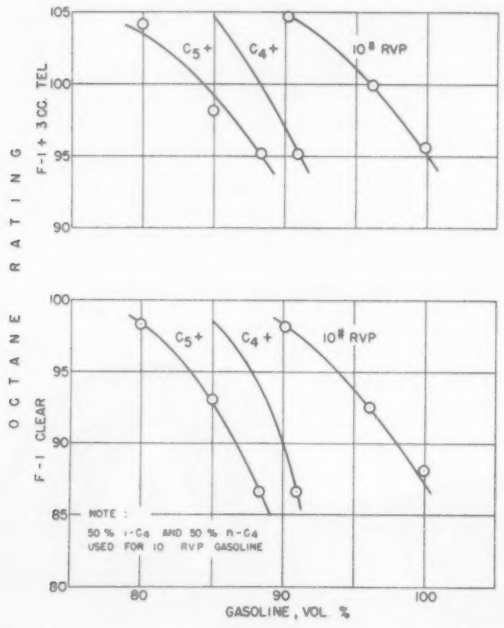


Fig. 1—(Left) Yield-octane relationships obtained with West Texas sweet mixed-base naphthas.

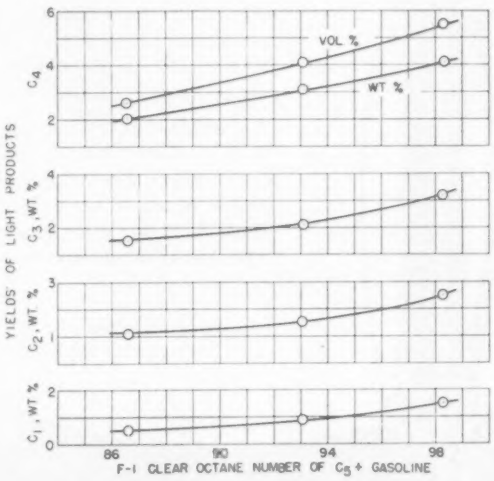
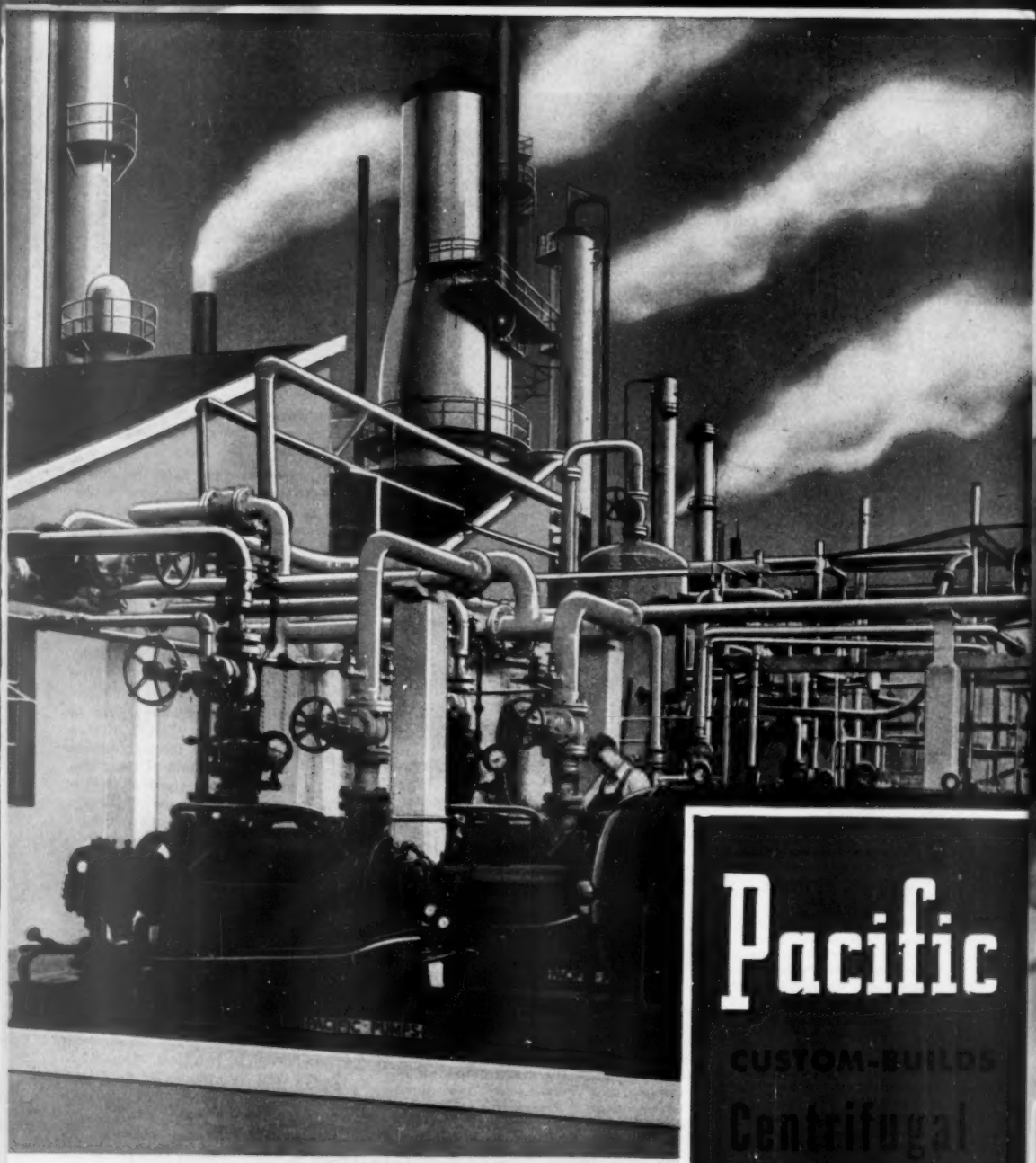


Fig. 2—(Above) Light-product distribution vs. octane number obtained from West Texas sweet mixed-base naphtha.



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increased at constant reactor inlet temperatures by a decrease in space rate.

A detailed summary of the operating conditions, product yields, and inspections of products is shown in Table 2.

Operating results . . . As indicated in Table 2, high yields of aromatics were obtained. Aromatics in product represented 46.0 per cent by volume of charge at the least severe operating conditions of 3.0 volume space rate and at 950° F. reactor inlet temperatures. The maximum possible quantity of aromatics in product, assuming 100 per cent conversion of the total naphthenes to aromatics plus the aromatics in the charge, is 46.4 per cent by volume of charge.

As shown by these data, the equivalent of essentially 100 per cent conversion of total naphthenes in the charge to aromatics was realized at the least severe operating conditions. It is apparent, therefore, that not only all of the cyclohexane homologs were converted to aromatics, but also all of the alkylcyclopentanes were converted to aromatics. This exemplifies both the excellent dehydrogenation and dehydroisomerization properties of the Houdriforming catalyst.

Reactor inlet temperatures were increased from 950° to 975° F. in order to obtain the data at the intermediate severity level. Operation at these conditions resulted in an aromatics yield of 50.5 per cent by volume of charge. When the space rate was reduced from 3.0 to 1.5 at reactor inlet temperatures of 975° F., the yield of aromatics further increased to 54.5 per cent by volume of charge.

At these latter conditions, approximately 8 per cent by volume of aromatics based on charge, or 25 per cent more aromatics, were obtained which could not be accounted for by conversion of the naphthenes available in the charge stock. These additional aromatics were undoubtedly obtained by aromatization of paraffins. Thus 22 to 25 per cent by volume of the paraffins in the charge stock must have been converted to aromatics.

These data indicate a substantial activity of Houdriforming catalyst for the aromatization of paraffins.

Gasoline production . . . The experimental data on the yields and octane numbers of the gasolines shown in Table 2 are presented graphically in Fig. 1. These curves indicate the yield-octane relationships obtained in this study. The 10-lb.-R.v.p. gasoline was obtained by pressuring with a blend of butanes containing 50 per cent isobutane and 50 per cent normal butane.

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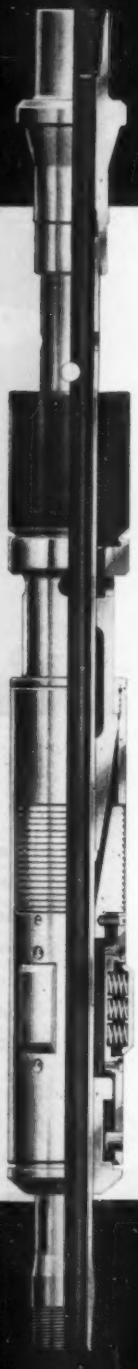

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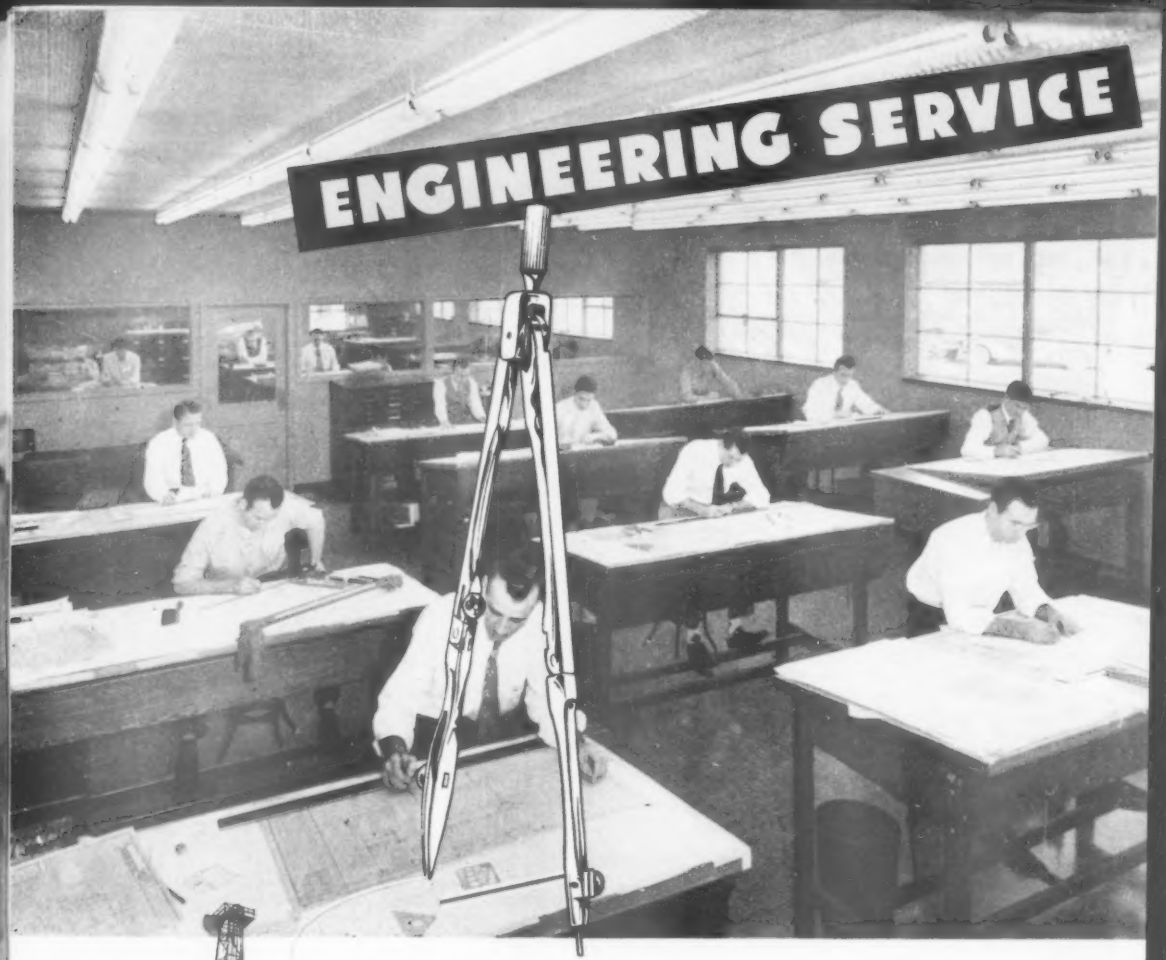

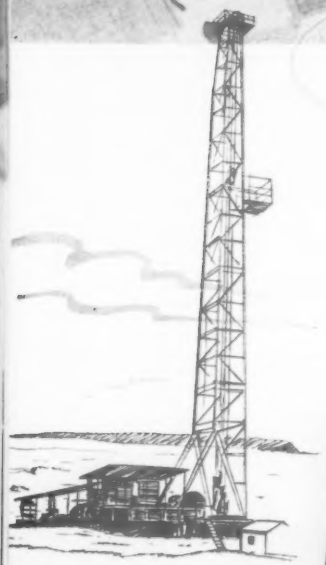

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This 10-lb.R.v.p. gasoline yield would be increased 1 to 2 per cent by volume if 100 per cent normal butane had been used for blending.

The run at the least severe conditions resulted in a C_5+ gasoline yield of 88.4 per cent by volume at an F-1 unleaded octane rating of 86.6. This gasoline, when pressured to 10 lb. R.v.p. with 2.6 per cent by volume of butanes produced, plus 9.0 per cent by volume of outside butanes, results in a yield of 100.0 per cent by volume of 10-lb.-R.v.p. gasoline. The 10-lb.-R.v.p. gasoline has a leaded (3 ml. TEL per gal.) F-1 octane rating of 95.7.

Operation at the intermediate severity level resulted in a yield of 96.2 per cent by volume of 10-lb.-R.v.p. gasoline which had an F-1 unleaded octane rating of 92.6 and a leaded (3 ml. TEL per gal.) F-1 octane rating of 100.0.

The run at the most severe operating conditions produced a C_5+ gasoline yield of 80.0 per cent by volume at the extremely high F-1 unleaded octane rating of 98.3. The leaded (3 ml. TEL per gal.) F-1 octane rating of the C_5+ was isooctane plus 0.44 ml. TEL per gal. The 10-lb.-R.v.p. gasoline yield for this 98.3 F-1 unleaded high-octane gasoline was 90.2 per cent by volume. This gasoline required 4.7 per cent by volume of outside butanes.

The preceding data indicate that excellent yield-octane relationships and very high octane numbers can be obtained with Houdriforming catalyst in a relatively low-pressure operation.

The gasoline obtained from the run at the least severe conditions was tested for color, stability, and gum content. The gasoline was not treated, nor were inhibitors used. The results are as follows:

Run	1
Color	+25
Copper-dish gum, mg.	1.4
Accelerated gum, mg.	1.1

The stability and color of this gasoline are excellent, and the gums are extremely low.

Light products . . . The distribution of light-hydrocarbon products obtained when this charge stock was processed is shown in Fig. 2 as a function of F-1 unleaded octane rating of the C_5+ gasoline. Very low yields of gaseous products were obtained. At the 98.3 F-1 unleaded octane level, only 7.2 per cent by weight of dry gas (C_3 and lighter hydrocarbons) was obtained. This consisted of 3.2 per cent by weight of propane, 2.5 per cent by weight of ethane, and 1.5 per cent by weight of methane. The yield of butanes varied from 2.6 per cent by volume at 86.6 F-1 unleaded octane number to 5.5 per cent by volume at 98.3 F-1 unleaded octane. The relatively low yields of light hydrocarbons are typical for Houdriforming.

Large quantities of hydrogen-rich gas were produced and obtained from the high-pressure gas separator in each of the three runs. The high-pressure gas "make" increased from 1,090 standard cubic feet per barrel of charge at the least severe conditions to 1,380 standard cubic feet per barrel at the most severe conditions. The hydrogen content of this gas decreased from 92.5 mol per cent to 85.0 mol per cent as severity of operation was increased.

TABLE 2—SUMMARY OF ADIABATIC PILOT-UNIT DATA

Charge stock—	West Texas sweet mixed-base naphtha (228 to 352°F. end point)		
Run No.—	1	2	3
Operating conditions—			
Space rate, vol. of oil per hour per vol. of catalyst	3.0	3.0	1.5
Inlet temp. (reactors No. 1, 2, and 3), °F.	950	975	975
Recycle-gas-to-oil mol ratio	5	5	5
Pressure, psig.	275	275	275
Operating data—			
Recycle-gas purity, mol per cent of H_2	92.5	89.5	85.0
High-pressure gas "make," s.c.f. per bbl.	1,090	1,210	1,380
Temp. drop, °F.:			
Reactor No. 1	149	164	174
Reactor No. 2	71	75	74
Reactor No. 3	22	22	15
Yields, per cent of charge—			
Aromatics, per cent by vol.	46.0	50.5	54.5
C_5+ gaso., per cent by vol.	88.4	85.0	80.0
C_4's, per cent by vol.	2.6	4.1	5.5
C_4+ gaso., per cent by vol.	91.0	89.1	85.5
10-lb. R.v.p. gaso., per cent by vol.	100.0	96.2	90.2
Extraneous C_4's for 10-lb. R.v.p. gaso., per cent by vol.	9.0	7.1	4.7
Propane, per cent by weight	1.5	2.1	3.2
Ethane, per cent by weight	1.1	1.5	2.5
Methane, per cent by weight	0.5	0.9	1.5
Hydrogen, per cent by weight	2.0	2.2	2.4

Inspections—	C_5+ gasoline	C_4+ gasoline	10-lb. R.v.p. gasoline	C_5+ gasoline	10-lb. R.v.p. gasoline	C_5+ gasoline	10-lb. R.v.p. gasoline
Gravity, °A.P.I.	46.2	47.8	50.6	44.3	48.3	41.5	45.5
A.S.T.M. distillation, °F.:							
Initial boiling point	181	123	98	162	92	149	95
10 per cent point	232	222	217	225	213	218	204
30 per cent point	249	250	259	249	251	247	249
50 per cent point	265	265	271	267	268	268	270
70 per cent point	286	286	290	289	294	290	297
90 per cent point	320	321	336	322	345	323	344
95 per cent point	336	341		340		342	
End point	365	371	366	374	376	373	379
Recovery, per cent by vol.	98.3	98.0	93.2	98.5	92.8	98.5	93.1
Reid vapor pressure, lb.	1.6	4.7	9.7	1.6	10.2	1.9	10.2
Sulfur, per cent by weight	Nil—0.002			Nil—0.002		Nil—0.002	
Octane numbers:							
F-1, without TEL addition	86.6	86.7	88.1	93.1	92.6	98.3	98.2
F-1, with addition of 3 ml. TEL per gal.	95.2	95.2	95.7	98.2	100.0	Isooctane +0.44	Isooctane +0.55
F-2, without TEL addition	77.9	78.3	79.2	82.1	82.4	87.6	87.2
F-2, with addition of 3 ml. TEL per gal.	85.7	86.0	87.6	88.0	90.1	91.4	93.5
Chemical composition, per cent by vol. of gasoline:							
Paraffins	45			38		31	
Olefins	2			2		1	
Naphthenes	1			0		0	
Aromatics	52			60		68	

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Long catalyst life . . . As was mentioned previously, the catalyst with which these data were obtained was in continuous use throughout this study. The greater part of the operation was carried out at the least severe operating conditions. During processing at these conditions, the yield of aromatics and the yield and F-1 unleaded octane rating of the C_5+ gasoline remained constant. Very little change was obtained in either the total temperature drop or temperature profile in each reactor. These are all indications of stable catalyst activity.

At the end of the program a check run was made at the least severe operating conditions in order to determine whether operation at extremely high F-1 unleaded octane levels had affected the catalyst adversely. This check run resulted in exactly the same yield of aromatics and the same yield and F-1 unleaded octane rating as was obtained earlier in the study. Thus operation at the more severe conditions apparently had no adverse effect on the catalyst.

Although only 3.4 bbl. of oil per pound of catalyst were processed during this study, indications are that several months of continuous operation could be obtained with little or no change in product distribution or quality.

Conclusion

1. Houdriforming catalyst can be used to reform commercially available naphthas at low pressure. Extremely high yields of aromatics are produced both by conversion of naphthenes and by substantial aromatization of paraffins. Excellent yield-octane relationships are obtained when motor naphthas are reformed.

2. Several months of continuous operation, with little or no change in product distribution or quality, are indicated when this stock is processed at low pressure.

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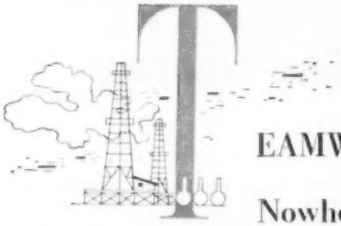

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Natural Gas in an Expanding Economy

by Ralph E. Davis*

IN the past 25 years, the annual consumption of energy has increased about 60 per cent. Coal consumption has declined; oil consumption has increased three times; and the consumption of natural gas has increased more than five times.

It is estimated that in another quarter of a century we may be consuming twice as much energy as we consume today. And if natural gas is sufficiently available, it may supply 25 per cent of that consumption, as against about 20 per cent now.

Even allowing for a wide margin of error, such projections put the spotlight on natural gas. They show the national urgency to find more gas. And they warn us to be prudent in the use of reserves already proved.

Peculiarities . . . Natural gas is unique among the sources of primary energy. Because, up to now, it has been discovered principally in the search for oil, efforts to find natural gas have been related more to the field price of oil than to the field price of gas. Field-gas prices have considerable bearing on the conservation and use of gas. In the past, gas prices have had little influence on exploratory efforts in the Mid-Continent and Gulf Coast areas.

Second, natural gas differs from oil in that it cannot, by present means, be transported in tankers; and it cannot be stored aboveground in large quantities. It is physically possible to import gas from Canada or Mexico, but not from Iran or the Far East. Our sources of future gas supply are, therefore, limited to North America and principally to the United States itself.

Finally, the price of natural gas to consumers is a function of public-utility regulation more than of the value of gas in competition with substitute fuels. In recent years, as coal and oil prices have risen, gas rates have fallen behind.

Gas prices to consumers fail to reflect the relative scarcity of gas as compared with substitute fuels; and because of the regulation and resulting low price, there is a national demand for gas which is not warranted by the available national supplies. Today, in many areas, it costs approximately $200 a year to heat an average home with oil; $145 with bituminous coal . . . but only $90 with natural gas.

Divided responsibility . . . These peculiarities add up to this: The natural-gas industry is only partially responsible for taking care of the nation's growing requirements for natural-gas service. It is largely up to the oil industry to find the necessary gas. And it is largely up to the regulators, particularly at the federal level to provide an atmosphere which will encourage the search for more gas and its wise and prudent distribution and use.

Certainly the record shows that in finding gas, the oil industry has done the larger part in the past. We must hope it will do so in the future. But we have no assurance that it will be able to find enough gas to take care of all the potential demands, especially under a regulation which prevents gas prices from reaching levels competitive with other fuels.

In the case of federal regulation, I do not believe the record has been favorable. It is becoming imperative that regulation take a more realistic approach, lest it continue to retard the national problem of finding and distributing the additional supplies of natural gas necessary to our growth and well being. Accordingly, most of my discussion to you today will deal with the development of regulation, its impact on the natural-gas industry, and what we ought to expect in the future.

Public-utility regulation . . . Public-utility regulation is usually reserved for certain types of economic public-service activities which, by their very nature, are monopolies. Generally speaking, it has not been found economical to have two electric, telephone, or gas companies in the same community offering identical service to the same local customers. The three principal matters regulated are: prices or rates; quality of service; and extensions or abandonments of service.

Public-utility regulation developed gradually in this nation, beginning in the final quarter of the nineteenth century. In several important instances about the turn of the century, state legislatures gave to municipalities the authority to regulate retail rates charged by local utilities.

Several principles, basic to the public-utility tradition, became generally accepted: First, the administrative agency had no powers not given it by the legislature, which means that regulation is essentially a legislative function; second, in determining rates, the agency must not bring about confiscation, and must allow the company a reasonable return on its investment; and, finally, the question of whether a rate yielded a reasonable return was a judicial one; reasonableness of rates was a matter of law, not the arbitrary judgment of commissioners.

The 50 years of growth of public-utility regulatory principles developed at the state level rather than in the federal Government. Except for common-carrier regulation of railroads, the national Government did not enter this field until about 1935, only 17 years ago.

Conservation regulation . . . In roughly the same half century that public-utility regulation was developing, states producing oil and gas were working out principles for the physical conservation of oil and gas. Conservation policies gradually came to be accepted, provided they passed one of these tests: (1) They prevented physical waste, underground and aboveground, in a reasonable manner; or (2) they protected the correlative rights of owners in a common pool.

In this conservation development, the federal courts recognize that production of oil and gas is essentially a mining operation. As such, it has been a local matter, to be regulated by the states rather than by the federal Government, even though the mined product is destined for interstate commerce. The problems of conservation were considered, and properly so, primarily problems of the states.

Federal regulation . . . The Natural Gas Act of 1938 conferred upon the Federal Power Commission the duty to regulate the rates charged by companies doing

*Consultant, Houston. Presented at thirty-second annual A.P.I. meeting, Chicago.

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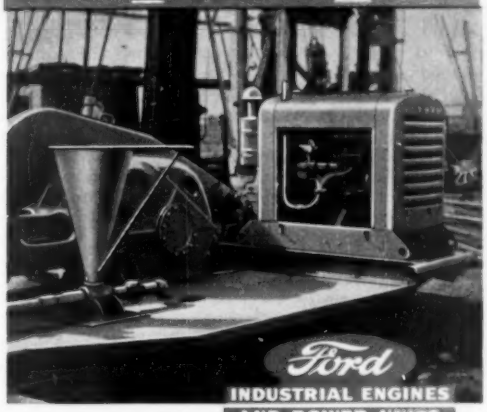

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an interstate business in natural gas. Thus the Natural Gas Act is public-utility regulation, directed at companies transporting and selling natural gas in interstate commerce, for resale, rather than conservation regulation directed at the natural gas itself or the producers thereof.

In order to understand better the impact of this federal regulation, we should look briefly at the industry in the days before such regulation began.

The background . . . At the turn of the century, the annual consumption of natural gas was around 100 billion cubic feet. In the next quarter century, it increased steadily until, by 1925, it reached 1.2 trillion cubic feet.

Until that time, the principal markets for natural gas were near the fields of production. The development of seamless pipe of better steel and other technological improvements began to make it economical to transport natural gas much greater distances. As a result, in the late 1920's there were some important pipe-line expansions.

In the depression years of the 1930's, the natural-gas industry experienced very little growth because coal was cheaper than natural gas in many large markets, and money was tight. As a result, the nation developed a backlog of "surplus" natural-gas reserves during the depression decade.

Even with the expansion in use of natural gas before the days of federal regulation, we were experiencing declining prices because supply was generally greater than demand. In 1922, when natural gas accounted for only 4 per cent of the nation's energy use, the average value of natural gas at points of consumption reached a peak of 29 cents per thousand cubic feet. From then on, the average cost to consumers decreased; while, at the same time, the value of gas at the well declined even more sharply. In 1922, the average was 11 cents; by 1940, it was only 4.5 cents.

The continually widening spread between values at wells and at points of consumption reflected in part the greater expenses of transportation as gas was transported to markets more distant from points of production. However, I believe that, more importantly, it reflected the age-old economics of growth of supplies far in excess of demand.

The existing unfavorable price relationship between natural gas and competing fuels in populous markets at great distances from the new supply areas discouraged early pipe-line expansions. Demand did not keep pace with supply, and this fact was reflected in declining field prices.

When federal regulation began in 1938, natural gas had a very low field value in many areas, and there were very large supplies of gas searching for a market at almost any price. On the other hand, at many major consuming points natural gas was expensive relative to competing fuels. Thus, there was little cause for industry expansion.

Industry growth . . . The mere imposition and administration of federal public-utility regulation could not rouse the natural-gas industry from its doldrums. Expanding markets were required. Such markets began to appear as coal prices rose, and as the national demands for all forms of energy began to increase under the influence of the war effort.

In the 1940's and continuing into this decade, the industry has experienced its major period of development. The market expansion has been national in scope, so that the transmission from sources of supply to such new markets has increasingly assumed an interstate character. At the same time, there have been major expansions in gas consumption within the natural-gas producing states themselves.

The recent expansion has been possible because of the tremendous backlog of gas reserves which was built up during the 1930's. Now these are largely contracted for, so that the growth of the industry in the future will depend upon the success in finding more natural gas. Therefore, it is important to consider critically those aspects of federal regulation which have a bearing on the future supply and distribution of additional natural-gas reserves.

Future growth . . . There are many important ways in which the administration of the Natural Gas Act affects the supply and distribution of natural gas. I would single out two for particular discussion, because I believe that, unless the Federal Power Commission becomes realistic in its approach to these two points, the natural-gas industry will have greater difficulty in meeting the growing demands being made upon it.

Threat of field price regulation . . . A critical effect which the administration of the Natural Gas Act has had upon the field supply of natural gas has been that it has discouraged the sale of gas reserves to interstate pipe lines. Many oil companies, controlling a substantial portion of the nation's proved gas reserves, have been unwilling to sell gas to such markets, because they wished to avoid federal regulation. Thus major natural-gas supplies, which might by this time have been dedicated to national markets, are still physically available and undedicated to any present use.

This situation is a result of indecision on the part of the Federal Power Commission as to the meaning of Section 1 (b) of the act. That section defines the aspects of the industry to be regulated, and excludes production in these words: ". . . but shall not apply . . . to the production or gathering of natural gas."

In one of the early jurisdictional cases in 1940, the commission decided that a company which drills wells, produces gas, gathers it, and sells it to a pipe-line transmission company is excluded from commission authority, under the language of the act quoted above. But one of the commissioners dissented, saying that: "It is the sale which is the jurisdictional activity, not the mere acts of producing and gathering. . . . The sale was not part of the production and gathering, and therefore the sale was not exempt. . ." If that commissioner had had his way, then every company which sold gas in the field to interstate pipe lines, either directly or indirectly, would be regulated as a public utility. It is no wonder that natural-gas producers were disturbed by such an interpretation.

In 1947, the commission issued a formal statement, saying that it would not assert jurisdiction over producers and gatherers as such. But when the Kerr bill was vetoed, the commission changed its mind, and rescinded the 1947 statement. Then it investigated Phillips Petroleum Co. as a test case, to decide the question of jurisdiction. Again its decision was the same as it had been in 1940. And again a commissioner dissented, in this case Buchanan. He felt that the commission should have asserted authority over Phillips. So this threat of field-price regulation, and of federal regulation of natural-gas production is still with us.

This threat has a great deal to do with current field-price trends. As public demand outstrips the growth in available supply, the problem of finding the necessary gas is becoming serious for many companies. Instead of looking for gas at former prices of 8 and 10 cents at the well, some transporters serving major consuming areas of the nation foresee field prices of 15 to 20 cents and higher. Even at such

higher prices, it is probably better economics to contract for 500 billion cubic feet of gas or more from a single seller, rather than to turn away new demands in the consuming areas.

Transmission companies as gas producers . . . The administration of the Natural Gas Act has discouraged exploration and development of gas reserves by regulated companies. In 1940, the eight major interstate pipe lines then operating produced nearly half of the gas they transported and sold. But every large system authorized and constructed since that date has relied almost entirely upon gas purchased from others, to the exclusion of ownership of its reserves.

As additional field supplies become increasingly difficult to find and costly to buy, it would be to the advantage of consumers at the end of long transmission lines if the regulated pipe-line companies were actively engaged in searching for additional reserves to take care of market growth. A transmission line could adjust its field development and rate of well production to accommodate its line facilities and seasonal variations in demand. Furthermore, it could take gas from its own reserves at variable rates to offset the more rigid contractual obligations and delivery performance of purchased gas.

Many recent contracts contain a "favored nations" clause, which requires that the transmission line grant the supplier an increase in the price of gas each time the line makes a new gas-purchase contract at a higher price. At times, a transmission line may need a relatively small volume of additional gas to compensate for accelerated depletion of one of its gas supplies, or to take care of additional sales or increased line capacity. The additional volume of gas may not be available at the same price paid previously for contract gas. In paying the new higher price, the transmission company automatically is obligated to pay higher prices for gas purchased under older contracts from the same district.

The Office of Price Stabilization and the Federal Power Commission have indicated recently that they would oppose the operation of the favored-nations clause. And the commission has hinted that it will not grant rate increases to compensate for the increase in gas cost resulting from the application of the clause. If transmission lines developed their own reserves, the effects of the clause would be minimized.

The nation needs to find more gas. The long-distance pipe lines, in particular, have a vested interest in developing additional reserves in order to take care of their markets and to prolong the value of their pipe-line investments. The FPC can encourage the development of additional reserves if it uses a commodity-value approach to company-owned reserves, rather than the present totally inappropriate public-utility approach. As Mr. Justice Jackson has written:

"For good or ill, we depend on private enterprise to exploit these natural resources for public consumption. The function which an allowance for gas in the field should perform for society in such circumstances is to be enough and no more than enough to induce private enterprise completely and efficiently to utilize gas resources, to acquire for public service any available gas or gas rights, and to deliver gas at a rate and for uses which will be in the future as well as in the present public interest."*

Until the commission does bring its policies into agreement with the economics of the natural-gas industry, then the industry must continue to depend largely upon the oil industry to find the required additional gas reserves.

Rate base regulation . . . The other important aspect of federal regulation which affects the future of natural-gas supply is rate making. In order to fix rates, the commission determines a rate base on which the regulated company is permitted to earn, and then determines a rate of return which is thought to be fair and reasonable. In such a formula for determining "reasonable" price or rates, consideration is not given to the commodity value of natural gas either at the well or at the market.

In applying the public-utility pricing formula, the commission has chosen to use original cost of properties as the proper measure of the rate base. Whatever merit "original cost" may have from the standpoint of valuing man-made facilities like pipe lines, it has no merit at all from the standpoint of valuing natural gas itself. For it proceeds on the false assumption that there is some relation between the "cost" of finding gas and the "value" of the produced gas itself. It is not necessary to tell people in the oil business what is wrong with that theory.

Some interstate pipe-line companies own their own reserves, and produce a substantial portion of the natural gas which they transport and sell. Under federal regulation, these companies are required to carry such gas on their books at "cost." As the gas is produced, the book value of the investment is amortized proportionately. The price of gas accordingly moves progressively downward as gas becomes scarcer and scarcer. By such low prices, gas consumers suffer an illusion of growing plenty instead of realizing the fact of growing scarcity.

The absurd conclusion has been reached in some cases, where the field market value is actually increasing, that a regulated company is required to carry its gas reserves on its books at near-zero value. In effect, such a company is required to give the gas away to consumers hundreds of miles from the point of production, but is permitted to charge a rate sufficient to cover the transportation costs.

In the Hope Natural Gas Co. case in 1944, Mr. Justice Jackson argued that the FPC and the courts should get away from the rate-base method of determining the field value of natural gas under federal jurisdiction. He said the value should be determined along economic lines; the standard should be not the fair return on the rate base of a particular producer, but the value of the gas as a commodity in competition with other gas from other producers. As he said: "The emphasis would shift from the producer to the product . . ."*

Mr. Justice Brandeis, a man who strongly favored federal regulation of public utilities, said this about the gas industry: "If natural-gas rates are intelligently to be regulated, we must fit our legal principles to the economy of the industry, and not try to fit the industry to our books."†

Commissioner Nelson Lee Smith, of FPC, objected recently to the commission's policy of including natural-gas reserves in the rate base, and offered a solution when he said that the traditional rate-making policies of the commission in respect to pipe-line gas have the effect of discouraging and destroying the incentive to search for and produce gas. He continued: ". . . the remedy lies largely in our hands . . . As a practical matter of very real advantage to the consuming public . . . pipe lines should be encouraged to find, develop, attach, and retain in public service their own reserves of natural gas in substantial proportions . . . We are not legally bound to our present rate-making policies regarding pipe-line produced gas . . . we should endeavor to develop a more realistic and less short-sighted view of this entire matter."‡

These quotations from two justices of the Supreme Court, and from one veteran member of the commission, indicate to me that there is no legal reason why the commission must apply public-utility pricing to natural gas at the well. It seems to be merely a matter of commission preference. The commission could change its mind and bring its policies into closer relation-

*FPC et al. vs. Hope Natural Gas Co. 320 US 491.

†Penn vs. W. Va. 262 US 553.

‡FPC opinion No. 230, Docket G-1618-Northern Natural Gas Co.

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ship with the realities of the industry. This would certainly be desirable from the standpoint of the national interest.

Rate of return regulation . . . As mentioned earlier, in fixing rates the commission determines a rate base on which the regulated company is permitted to earn and then determines a rate of return which is thought to be reasonable.

It has long been recognized that one of the factors to be considered in determining a fair rate of return is the cost of money. But what the commission has now done is to say that fair rate of return and cost of money are synonymous and has recently used that theory in two important rate cases.

In developing its over-all cost of money, the commission took the actual interest cost paid on debt and the actual dividend rate paid on preferred stock. It gave weight to these costs in the same proportion as debt, and preferred stock was of total capitalization. The commission disregarded the fact that current interest rates are higher than the rates the companies are paying and this was a very important fact in one case because the company has a substantial portion of its debt in the form of serial maturities.

But the real trouble with the commission's approach was on the common-stock side. In one case, the commission allowed 8.75 per cent for common-stock money. In the other, it allowed 8.45 per cent. In both cases, the amounts are exclusive of 0.5 per cent allowance for flotation costs. In support of the amounts allowed, the commission referred to what it called an investors' appraisal of seven natural-gas-company stocks. The commission determined for a period beginning with 1946 the arithmetical relationship between the market value of the common stocks of the seven companies and the related earnings.

What is a "fair return"? . . . The rate of return on a utility rate base should, in the public interest, be the lowest practical rate that will insure continued good service. A higher rate is not necessary. A lower rate endangers the quality of service.

If transmission and distribution lines, with other necessary facilities, are to be built to serve the public, the money to pay for them cannot be had from the investing public unless these regulated companies earn enough to make their securities sufficiently attractive for buyers to want to own them. Unless this condition prevails, new facilities cannot be financed; and, as a result the consumers will not be able to get proper service.

In effect, the commission's new policy tells the investor that, in a market where money is earning more, his dollars will be allowed to earn even less if he puts them into the expansion of the natural-gas business. If the commission pursues this policy, it will be impossible for existing companies to take care of normal market growth. A rate of return which has that effect is not a fair rate.

The industry today . . . Today, we have a natural-gas industry which rests on a broad foundation of adequate reserves, which is soundly financed and efficiently operated.

But it is an industry which is plagued by forces outside its control. Where gas is cheap in comparison with competing fuels, consumers are demanding more and more gas. The FPC keeps natural-gas prices too low by refusing to permit rate increases, or by permitting only partial increases.

Furthermore, the commission is making it difficult, and more difficult, for regulated companies to expand gas service. It takes two things to increase gas deliveries in interstate markets—gas reserves and money. The commission's policies discourage the exploration for reserves by regulated companies, and discourage the sale of gas in the field by nonregulated companies. On the money side, the commission makes it increasingly difficult for transmission lines to obtain the necessary financing to expand pipe-line facilities.

The industry in the future . . . The picture of today is a warning for the future. The FPC can destroy all incentive and all possibility for industry growth. But the FPC itself cannot satisfy the growing energy requirements of the nation, nor supply the gas which far-flung markets are demanding.

It was private enterprise which built a natural-gas industry in the half century and more before federal regulation. It was private industry which brought natural-gas service to its present state of excellence, in spite of the hobbles and road blocks invented by the commission. It will have to be private enterprise which ministers to the needs of the markets of tomorrow. But it can do so only in the measure that the FPC permits the industry to get the necessary reserves and the necessary financing.

I believe it in the public interest that the natural-gas industry be kept healthy and kept growing. But it may have to fight for its life against regulatory processes that would destroy it by slow and stealthy erosion. I heartily urge you to use your influence in any way that can be helpful to this industry which is so vital to our national well being.

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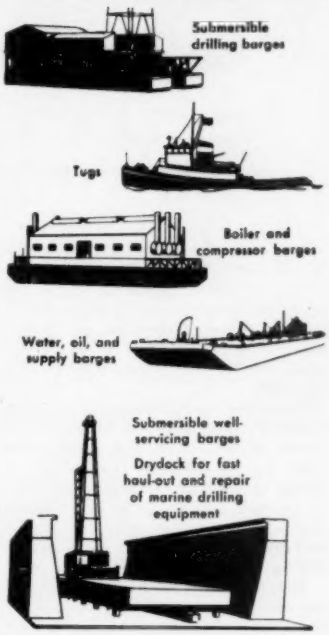
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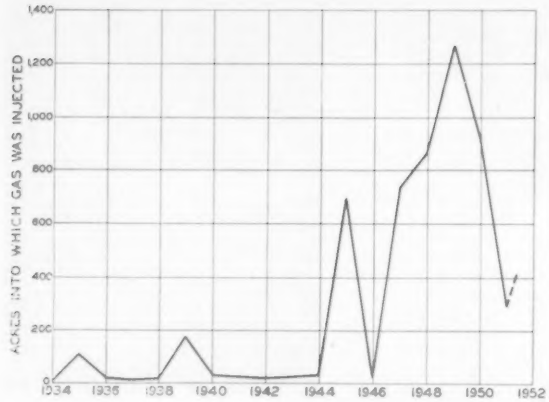

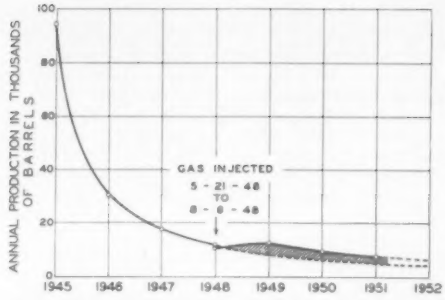

(Left) Acreage into which gas has been injected in Bradford and Allegany fields over the last 17 years. Fig. 1.

(Above) Oil-production decline curve for first Bradford field experiment, arithmetic scale. Fig. 2.

Gas Injection in Water-Flooding Operations

Here are the results of a survey of the activities in gas injection before and during water flooding in Bradford and Allegany oil fields. Data show that 10 to 15 per cent more oil may be recovered by preliminary gas injection.

by J. N. Breston*

THE experience of 11 Pennsylvania oil operators indicates that more oil is produced by preliminary gas injection before water-flooding operations. Data show that 10 to 15 per cent more oil may be recovered by this injection.

Increased oil production was also obtained when gas was injected into leases which already had been under flood for a number of years. The increase varied from 10 to 200 per cent of the rate which existed immediately before gas injection was started. In only one instance did the gas injection fail to increase the production rate.

Gas injection ahead of water flooding seems to be generally applicable. In addition to increased oil and gas production, other benefits noted are increased water-intake rates, more efficient flooding operations, higher crude-oil gravity, and reduction in wax problems.

When water has been previously injected, the additional gas is expected to produce more oil by increasing the free-gas saturation, improving the mobility of the oil, and by solution of the interstitial paraffin.

Scope of Field Activity

To date gas has been injected into over 1,500 wells on at least 72 leases affecting approximately 5,100 acres in the Bradford-Allegany fields. Of the total acreage, 4,500 acres are in Bradford field and 600 acres in Allegany field. Of the total number of leases 65 were subjected to gas injection before water flooding and 10 were under flood from 4 to 12 years prior to gas injection. The sands which were subjected to gas injection are the Bradford Third in Bradford field, and the Penny, Richburg, Waugh and Porter, and Scio in Allegany field. The total amount of gas injected into these reservoirs to date is approximately 775 million cubic feet.

Some idea of the activity may be obtained from Fig. 1 on which is graphed the acreage into which gas was injected over the past 17 years. It will be noted that the most intense activity occurred over the past 5 years. The decline in acreage involved during 1951 does not reflect the increased interest and number of applications, but probably the decline in drilling rate which was not up to normal during that time.

Characteristics of the Reservoir

The pattern in all cases was the conventional five-spot with the spacing between water wells ranging from 300 to 350 ft. For the Bradford sand the reported net sand thicknesses ranged from 17 to 55 ft. In Allegany field, tests are being made in the Penny, Richburg, Scio and Waugh, and Porter sands. The sand thickness in these varies widely, and in some instances as many as three separate sands are being produced through the same wells. In practically all cases the production is being pumped, although in at least one instance gas has been injected into a lease which is being produced by flowing.

In the Bradford Third sand the air permeability of some layers ranged as high as 225 md. but in general averaged about the same as for the Bradford field sands and ranged from 2 to 160 md.

Oil and water saturations in the Bradford sands prior to gas injection were reported to average approximately 45 and 25 per cent of porosity, respectively. In one lease subjected to gas after flooding the oil saturation was estimated to be 45-50 per cent and the water saturation was possibly as high as 50 per cent. In Allegany field sands the reported oil saturations ranged from 33 to 43 per cent and averaged 39 per cent of porosity. Water saturations were approximately 26 per cent. The sands which were already depleted by water flooding before gas injection were indicated to contain approximately 30 per cent oil and 40 per cent water.

Some of the Bradford as well as the Allegany field sands showed evidence of layers which are commonly called "water soaked" even on leases which were not as yet subject to intentional

*Pennsylvania Grade Crude Oil Association Research Laboratory, Bradford, Pa. Presented at Eastern District spring meeting, A.P.I. Division of Production, Pittsburgh, 1952.

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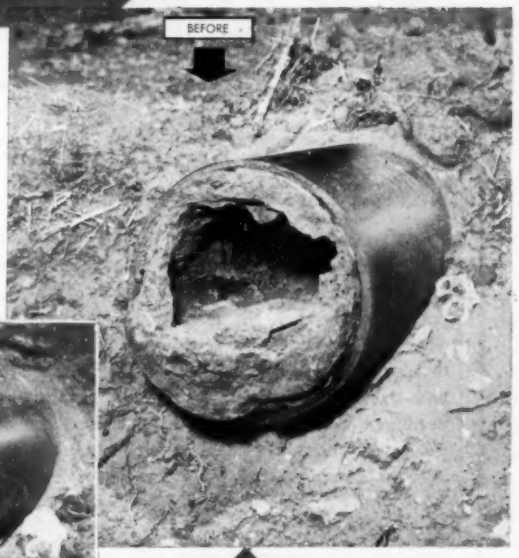

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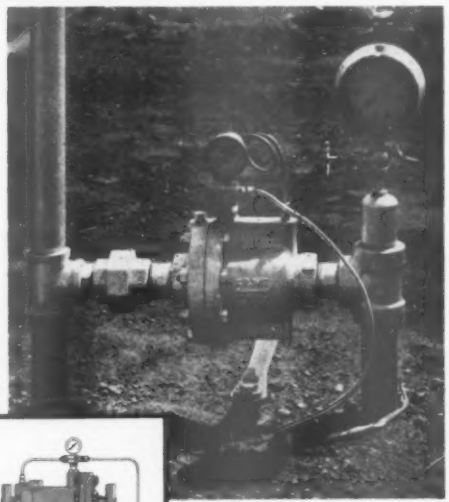

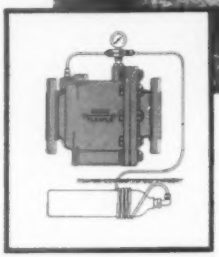

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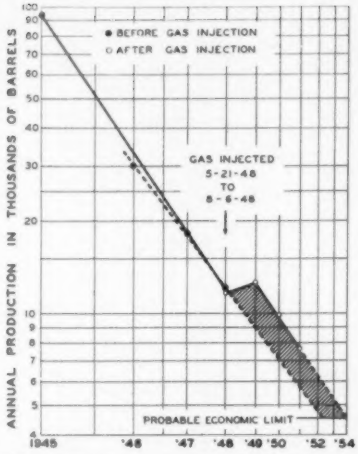
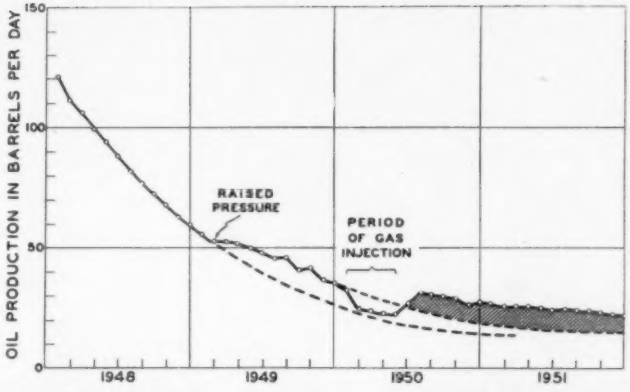


Oil-production decline curve for first Bradford field experiment, log-log scale. Fig. 3.



Oil-production decline curve for second Bradford field experiment, arithmetic scale. Fig. 4.

water flooding. This condition is generally attributed to old leakers or unrecorded "dump" floods.

Gas Injection

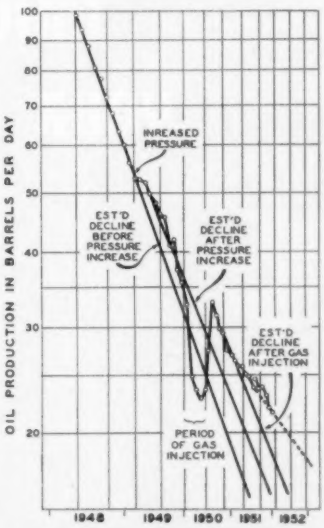
The gas injected was anything from dry gas to extremely wet lease gas, and was combined in all possible ratios. Generally, less than half of the gas injected was purchased gas; the remainder was produced on the same lease or another one belonging to the same company. Seldom was purchased gas injected into an entire lease before water was injected. Either the company had some excess lease gas from another project which was already producing, or the lease was developed in stages. That is, gas was injected into a portion of the lease and water turned in. The gas production from the producers on that portion would be collected and injected into another portion of the lease, and so on until the entire property had gas injected into it. Such a development program required a minimum amount of purchased gas and prevented an excess of "flush" gas.

Gas-injection methods varied from single-well operations to blocks of wells. The number of wells per block varied from 2 to 10, depending on the amount of gas available, pressure, compressor capacity, and the rate at which the wells would take the gas. On one lease where the wells took gas at low rates as many as 24 wells were being fed from one compressor. The general practice was to inject gas into a number of wells and watch the gas pressure on the producing wells that would be affected. The gas pressure would build up on the producing wells in anywhere from 2 to 70 days and most often showed up in 2 weeks. On the properties which have already been under water flood the average time is somewhat greater. As would be expected from the extremely variable conditions in the reservoir and the methods of injection, the gas-pressure increase in the producing wells varied widely. In some instances it went as high as 100 psig. If and when the gas broke through, gas injection would be curtailed or stopped on those wells from where it was suspected the gas was coming. Thus an attempt was made to balance the gas injection by results at the producing wells. In general, care was taken to avoid an out and out gas drive. Present operations still follow this same practice.

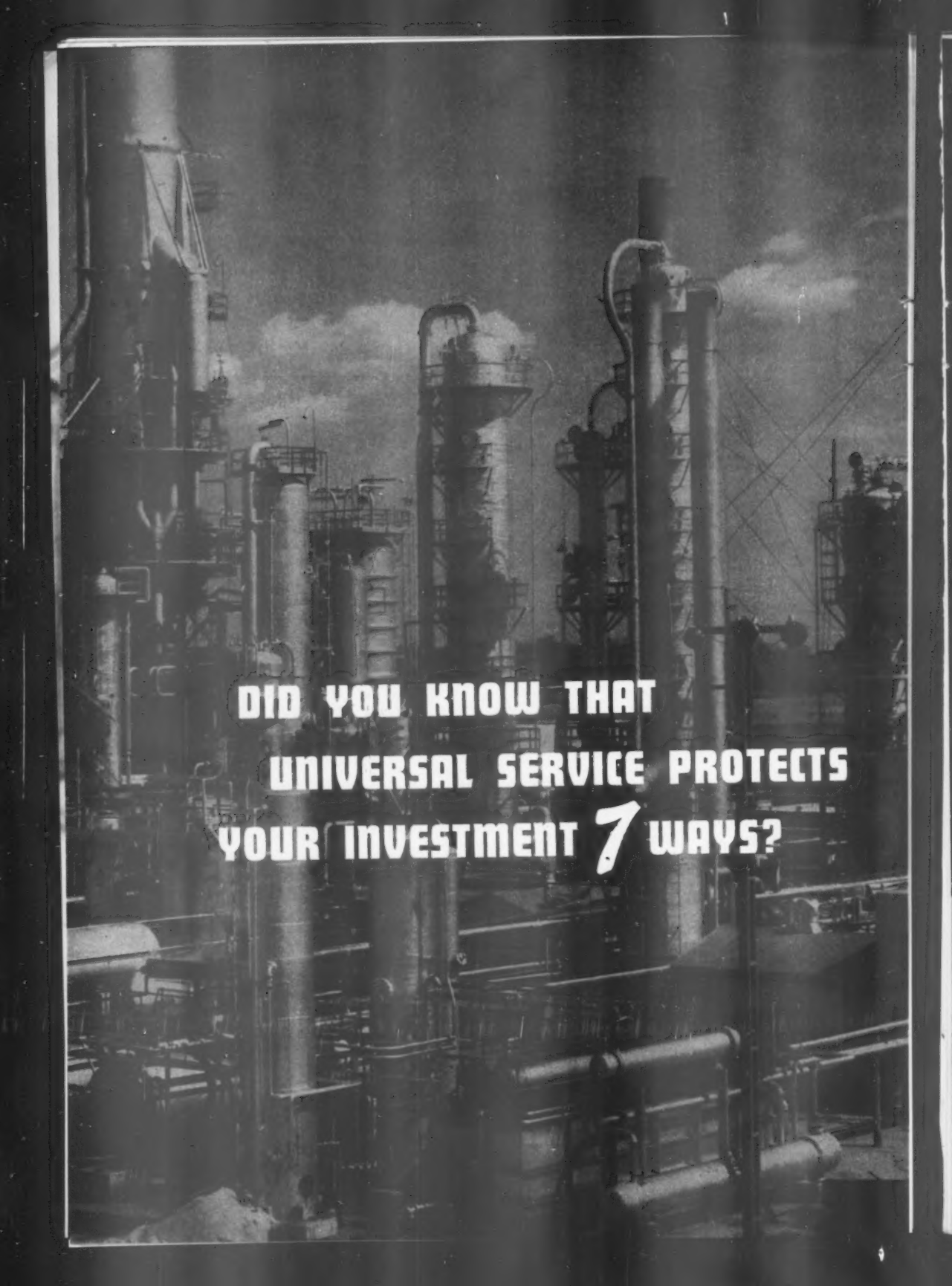
Gas-injection pressures at the surface varied from 100 to 500 psig. for unflooded Bradford Third sand. In general, gas injection was started at the lower pressure and then built up gradually to the top pressure of 500 psig. Pressures of from 550 to 650 psig. were required to inject gas into the Bradford sand that was already being water flooded. These pressures are 10 to 50 per cent below the waterflood well-head pressures. In Allegany field gas-injection pressures varied from 125 to 400 psig., with two operators injecting gas into the Richburg sand at pressures up to 750 psig. One of them used a pressure of 800 psig. to inject gas into some depleted Richburg sand which was being produced by flowing. The injection well-head pressures during flowing were 900-1,100 psig.

As would be expected from the variation in permeability and injection pressures, the average rate of gas injection varied from 0.20 to 0.96 M.c.f. per foot per day into the Bradford sand before flooding. The gas-injection rate into sands already being flooded was only about half that into the unflooded sand. Injection rates into the Allegany field sands varied from 0.02 to 0.91 M.c.f. per foot per day, reflecting the extremes in sand permeability and injection pressure. Gas injection into a flooded out Richburg sand of 0 to 17 md. permeability averaged 0.14 M.c.f. per foot per day.

The total amount of gas injected in the Bradford sand varied from 3.6 to 8.9 M.c.f. per acre foot of sand and averaged approximately 6 M.c.f. per acre foot. That injected into Bradford sand already under flood averaged about 7 M.c.f. per acre foot. In Allegany field the amount of gas injected varied



Log-log oil-production decline curve for second Bradford field experiment. Fig. 5.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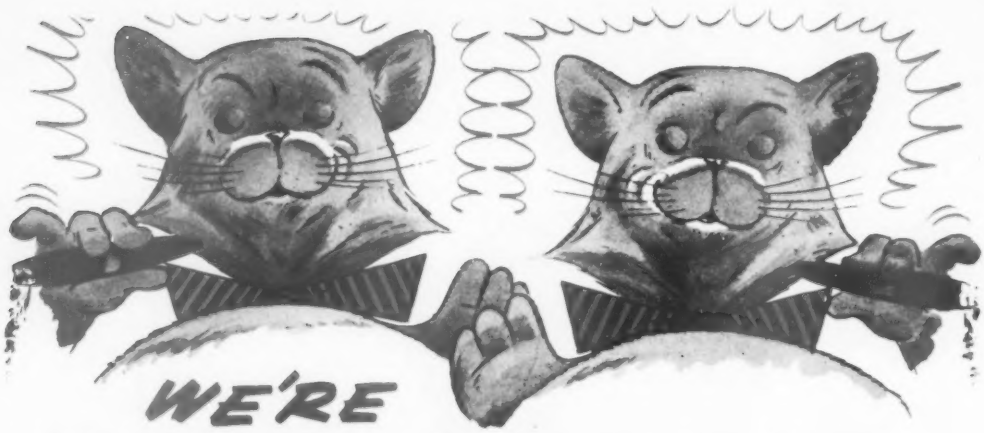

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from 1.6 to 18 M.c.f. per acre foot with no significant average being calculable. Apparently there was no other technical reason advanced for limiting the amount to be injected per acre except that of trying to avoid an out and out gas drive. Calculations based on a porosity of 16 per cent indicate that an average of 0.85 pore volumes of gas at atmospheric pressure were injected into the Bradford field leases on which there was no prior flooding. That injected into flooded leases was approximately 1 pore volume. For a 25 ft. net sand reservoir of 16 per cent porosity that would be approximately 150 M.c.f. per acre. In Allegany field the amount injected actually varied from 35 to 400 M.c.f. per acre.

Wherever the figures were available, a survey was made of the costs of gas injection. It indicates that for labor, supervision, fuel, materials other than injection gas, and depreciation, the cost ranged from 23 to 33 cents per thousand cubic feet of gas injected. On large-scale operations this cost will drop to only half that amount.

Water Intake After Gas Injection

From 13 producers who would volunteer some estimates of the effect of the gas injection on subsequent water intake rates, the following digest was obtained:

TABLE 1

Effect of Gas Injection on Water Intake Rate

Effect Noted	Number of Instances
Started below normal* than rose to normal intake	4
Started at normal intake, and continued at normal intake	3
Started at normal then rose to a rate above normal	7
Started at a rate above normal then declined to normal rate	3
Stayed below normal or decreased to below normal	1

*Normal rate estimated from behavior of similar wells without gas injection.

It was interesting to note that of the 10 instances where the water-intake rate started or stayed above normal after gas injection, 4 were operations where water had already been injected for varying lengths of time before gas injection. On two Bradford leases into which gas was injected during flooding, the water-intake rates started out higher right after the water was turned in again, then slowly decreased and leveled off at the rates which prevailed before gas injection. One Allegany field test showed the same results, and another shows the increased intake rate to be continuing.

A survey of the experience with gas injection on 76 leases in Bradford and Allegany fields indicates that in no reported instance was there any unusual difficulty in getting the water started in. In some instances there was some indication of a temporary plugging due to "Jamin action." This was evidenced by a slowly increasing intake rate which persisted anywhere from ½ to 6 months before it leveled off or declined. The reported increases varied from 15 to 100 per cent of the intake rate immediately after resumption of water injection.

Oil Production

Where gas was injected prior to flooding, substantial oil production usually commenced from 2 weeks to 3 months after water injection was started. Only two producers suspected that their production was delayed by gas injection after allowing for the time spent while injecting the gas. All but two indicated that in their estimation the production rose faster and peaked at a higher rate than they had anticipated. Most of the producers also reported that the peak production rate was maintained for a longer time than they had anticipated. Some indicated that when the decline came, it was slower than they had expected.

Based entirely on opinion and production to date, seven operators in Bradford field and four in Allegany field believe that more oil will be produced up to the economic limit due to preliminary gas injection. The experience of these operators accounts for nearly 90 per cent of the acreage into which gas has been injected. Three operators whose experience with gas injection dates back 8 to 10 years believe that "from 10 to 15 per cent more oil was recovered due to gas injection before flooding."

Some information is available on eight experiments in which gas was injected into leases which already had been under flood for a number of years. In seven of the eight experiments increases in recovery rate were reported. The increase varied from 10 to 20 per cent of rate which existed just before gas injection. In only one instance did the gas injection fail to increase the production rate. No instances were reported of a decrease in production rate caused by gas injection except for that which occurred during and immediately after the time in which the gas was injected.

Complete data and production-rate curves were available on only two such experiments. Both occurred in Bradford field and were performed by operators who had sufficient control over the tests so the data may be considered reliable. One of the experiments was performed on a 104-acre lease which had been under flood for over 4 years before gas was injected. Two and a half years after the peak of oil production, gas was injected through the water-input lines into the producing formation for a period of 2½ months. During that time a total of 10,755,000 cu. ft. of gas was injected at an average rate of 140,000 cu. ft. per day, and at a pressure of 450 psig. Approximately 103,000 cu. ft. of gas was injected for each acre in the lease.

Figs 2 and 3 are graphs of the oil-production decline curve, one plotted on an arithmetic scale and the other on a log-log scale. It is rather obvious from a comparison of the actual production curve and the projected curve that there was an increase in oil-production rate. Since there was no other significant change in the operation of the lease the operator attributes greater oil production to the injection of the gas. After correcting for the loss in production while the gas was being injected, it can be estimated that the additional oil production from August 1948 to January 1952 amounted to 7,700 bbl. The additional recovery up to the probable economic limit will be approximately 2,250 bbl. which is due to the 2-year extension in the economic life of the property. The economic gain as estimated from the calculations outlined in Table 2 amounts to about $31,400. This sum if realized will be a considerable return on an investment of about $8,400. To this may be added the economic gain from the additional production that is being reported. These results are perhaps exceptional and it is probable that such results could be repeated on another property only under unusual circumstances.

TABLE 2

Calculation of Economic Gain by Gas Injection Into a Water Flood Project in the Bradford Field

Value of additional production 9,950 bbl. at $4.00 per bbl.	(A)	$39,800.00
Cost of Gas Injection		
10,755,000 cu. ft. of gas at $0.45 per M.c.f.		4,839.75
Labor, supervision, fuel, and miscellaneous, $0.25 per M.c.f.		2,688.75
Depreciation on compressor and other equipment		850.00
	(B)	8,378.50
Net Gain, (A) minus (B) Not adjusted for the cost of lifting the additional oil		$31,421.50

The other project on which comprehensive production data were available involved a 10-acre portion of a 30-acre lease which had been under flood for 3 years before the gas was injected. Approximately 2 years after the peak of production, wet gas was injected into four water-intake wells for a period of 6 months, and then the water was turned in again. A total of 3,782,000 cu. ft. of gas was injected at an average daily rate of 15,000 cu. ft. per well at a pressure of 530 psig. The gas injected per acre averaged 378,000 cu. ft. Injection was

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Figs. 4 and 5 are graphs of the oil-production decline curve, one plotted on an arithmetic scale and the other on a log-log scale. It will be noted that approximately 1 year before the gas was injected the water injection pressure was raised which shifted the decline curve and decreased its slope somewhat. During the period of gas injection oil production fell off sharply. When water injection was resumed, oil production picked up again rather rapidly and rose to a new production decline curve with a lesser slope. Where the production decline curve followed a straight line on a log-log plot, it has been demonstrated [12] that a sudden displacement or a sharp change in the slope of the curve will occur if there is some change in the operation of the flood. Such a relationship is illustrated in the production curves of Figs. 3 and 5.

In Figs. 4 and 5 it is apparent that the oil-production rate increased following the injection of gas. By estimating the area between curves it appears that up to January 1952 there has been a net increase in production of at least 1,460 bbl. of oil attributable to the gas injection. As estimated from the calculations outlined in Table 3, the economic gain up to January 1952, which is attributable to the gas injection, amounts to about $2,460 exclusive of the small cost of lifting the additional oil. If one can assume that the economic life of the property will be extended because of gas injection, then the net economic gain will be somewhat greater.

TABLE 3

Calculation of Economic Gain by Gas Injection Into a Water Flood Project in the Bradford Field

Value of additional Production (to Jan. 1952) 1,460 bbl. at $4.00 per bbl. (A)	$ 5,840.00
Cost of Gas Injection	
3,782,000 cu. ft. of gas at $0.40 per M.c.f.	1,512.80
Labor, supervision, fuel and miscellaneous at $0.41 per M.c.f.	1,565.51
Depreciation on compressor and other equipment	300.00
(B)	3,378.31
Net Gain, (A) minus (B) Not adjusted for the cost of lifting the additional oil	$2,461.69

In Allegany field comparative data were available on only one project in which gas was injected into a water flood after it had already been under flood for a number of years. The test area was within a 68-acre lease which had been under flood for 12 years. For over a year before gas injection, cleanout work on input wells was resorted to in an attempt to increase production. It was partly successful in that it raised the production rate from 33 to 41 bbl. per day. However, by April 1951 the production was down again to 32 bbl. per day. That month gas injection was started on five intake wells. The injection pressure started at 900 psig., then dropped to 700 psig., and an average of 300,000 cu. ft. of gas was injected into each well. During gas injection the production fell off to 25 bbl. per day and when water injection was resumed, the oil production increased sharply and rose to a peak of 49 bbl. per day. Between November 1951 and January 1952 the production was holding at the 44-bbl. per day level, approximately 12 bbl. per day higher than the production a year before. The average production for 1951 was 5½ bbl. per day higher than for 1950 and the only material change in production practice was the gas injection. Thus it was estimated that the increased production had already amounted to over 2,000 bbl. of oil valued at $8,000. The cost of injection, including the gas, was estimated at $1,500, which indicates a net economic gain of $6,500 already.

Gas Production and Utilization

In all but one of the projects reported on in Bradford field a substantial increase in gas production was noted soon after the gas was injected. Similar results are reported for over half of the projects in Allegany field. This increased rate of gas production persisted after the water was turned in and was maintained almost indefinitely. In some instances it has already lasted for years. There was also reported a noticeable increase in the B.t.u. value of the gas. Those operators who have made some measurements of the cumulative volume indicate that after deducting the volume of gas injected, the net gas production was two to four times that which could normally be expected from the oil production on such leases. Such results do not appear logical but the fact remains that nearly all operators made such reports. One possible reason which could account for the reported increase in gas production is more attention to gas collection and repairing of leaks. However, a check with the operators largely rules out such an explanation.

A number of operators illustrate the results by a comparison of gas bills before and after gas injection. For example, one of them reports that before gas injection his gas bills averaged $280 to $300 per month. For the 6 months that have elapsed since gas injection his gas bills have averaged from $50 to $86. He estimates that he paid $1,300 less for gas during the past 6 months because of the increased gas available on the lease. Considering

that he injected only $675 worth, he figures that he is already $525 ahead.

On one project in Bradford field where gas was injected after flooding was already in progress for 3 years, the gas production is still coming up steadily 1½ years after gas injection. Unfortunately in nearly all cases no attempt is being made to determine just how much of the injected gas is being recovered. In a few operations there is some evidence that little if any of the injection gas is being returned. In some cases the produced gas has been considerably enriched in B.t.u. value but not in volume.

In nearly all cases where there is surplus gas it is being reinjected on the same lease or on another one belonging to the same company. In this way gas is conserved so that a sufficient amount will be available over the entire economic life of the property. Most producers maintain that if there were no other advantages to gas injection in water flooding, the economic benefits of gas storage alone would justify gas injection.

In answer to the question, "Was there any noticeable change in the properties of the crude?" due to gas injection, the majority response was that the crude was much livelier and somewhat lighter in color. The lighter color may possibly be due to the heavier gas blanket which shielded the crude from air during pumping and storage and prevented it from becoming oxidized.

On none of the projects was there any paraffin trouble that could be attributed to gas injection. A number of operators indicated that there was less paraffin or, if there was any change, the paraffin was eliminated. A few operators in Allegany field reported that the livelier crude and extra gas helped to clean out their producing wells and thereby stimulated production.

General Discussion

All 14 of the producers interviewed were of the opinion that gas injection ahead of water flooding is generally applicable and worth while. Those who have been able to give it a reasonable trial are certain that they have benefited by it in one way or another. Besides the advantages of increased oil and gas production, such benefits as increased water intake rates more balanced (efficient) flood, decreased wax problems, etc., are reported. Some feel that the temporary plugging action of the gas in the more permeable sand layers helps to get the water started into the less permeable sand and thereby creates a more uniform oil bank. One producer even reported the discovery of three abandoned wells during gas injection on a property which has had high-pressure water on it for years. Where water has already been injected, the additional gas is expected by some operators to produce more oil by increasing the free-gas saturation, improving the mobility of the oil, and by solution of interstitial paraffin.

In response to the question, "Do you believe gas injection could possibly do any harm?" the answer invariably was in the negative. Those who qualified their answer gave the following reasons by way of explanation:

The dry gas may strip off the light ends of the crude and make it more difficult to move because of increased viscosity or wax precipitation in the formation.

The gas drive may reduce the oil saturation to a point where the water will not start an oil bank later on.

The increased gas saturation will cut the rate of oil production.

The gas if injected into low-permeability sand will plug it by Jamin action.

If it is injected into a high-gas-saturation sand, it will deplete the sand by gas drive and render it unfloodable.

It is very dangerous to fool around with high pressure gas in ordinary lease lines.

This last remark is serious and deserves some elaboration. Most waterflood operating personnel have had little or no experience with the handling of high-pressure gas, and generally are acquainted only with the handling of high-pressure water. A break in a water line ordinarily would not harm any persons who happened to be nearby except for a wetting. A blowup in a high-pressure gas line or fitting is the equivalent of an explosion, which may mean flying metal. The recommendation therefore is that anyone who contemplates the injection of high-pressure gas into lease lines should proceed with care, and entrust such operations only to those who would show the proper respect for the dangers involved.

Where there is danger of freezeup in the lines it has been found advisable to use some antifreeze in the gas. Freezeup can also occur in the tubing or well as has been experienced already. This can also be taken care of by alcohol injection, or by stopping long enough to allow the earth temperature to melt the freezeup. Gas injection should take place preferably in the summer when there is less danger of freezeup in the lines. Also, gas is more available in the summer and often a special price advantage can be had.

In conclusion the author wishes to reiterate that the observations reported are not intended to be construed as valid proof that gas injection in water flooding will make more oil or will be generally profitable. No doubt there are chances of no success at all along with possible dangers particularly if one does it indiscriminately. The results reported are mostly opinions and some of them can be interpreted in other ways. However, they are informative as well as interesting, and if proven true by further experience will herald one of the greatest developments in the practice of water flooding in the past decade.

In view of the considerable interest in the possibilities of gas injection along with water flooding there is a great need for well controlled field experiments. As part of its production research program the Bradford laboratory of the Pennsylvania Grade Crude Oil Association is initiating a small-scale field test of the effects of gas injection on water-flood recovery. The test will be performed on a property which has already been under flood for 10 years. In addition to a test with natural gas a nearly identical one will be performed in which engine-exhaust gas will be used.

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Microwave Control of Pump Station

(Continued from page 259)

off the line because of power failure or other cause.

To start the remote station, the operator observes the reading of the discharge-pressure recorder, which shows the line bypass pressure at the remote station when the latter is shut down, as well as the remote-station discharge pressure when the station is operating. The operator then adjusts the pumping rate to obtain the optimum bypass pressure for starting at the remote station. Pressing the start button transmits a tone signal via the radio which closes a relay at the remote station, thus instituting the starting sequence.

When the start impulse is received at the remote station in the form of a tone signal from the radio receiver, it operates a relay which, in turn, closes a contactor which causes a valve located in the station manifold to open, and this permits fluid to enter the main pumping unit. When this manifold suction valve reaches a full open position, contact is made which causes the main pump motor to start.

When the pump reaches normal operating speed, the manifold discharge valve opens and the station is on the line, subject to the operation of certain automatic pressure control which will be discussed later. The failure of any of the equipment to operate properly, or the loss of suction pressure during the starting sequence, automatically will cause the controls to return the station to standby condition. All controls are designed for fail-safe operation.

It requires about 2 minutes to complete the starting cycle. By observing the chart readings, the operator is able to increase the pumping rate at the initial station in order to utilize fully the extra line capacity as it becomes available by reason of the remote station's coming on the line. Pressing the stop button reverses the starting sequence and isolates the booster station from the line in standby condition. The stop-and-start buttons are the only manually operated controls on the console.

Fig. 4 is an interior view of the remote-station control building. The radio cabinet is on the right. The cabinet on the left houses all of the relays and switches which provide for the sequence operation, as well as the 2,300-volt starting equipment for the main motor. In the background is the standby electric-power generator. In the event of a power-line outage, enough power is available to close the manifold valves which isolate the station from the pipe line and to maintain radio communication until regular power is restored. Operation of the standby generator is indicated at the control console by a signal light.

Safety . . . The booster station has a single pumping unit consisting of a 700-hp. explosionproof electric motor which drives a six-stage centrifugal pump. The pump is rated at 35,000 bbl. per day at a differential pressure of 900 psi. when gasoline is being pumped. The motor and pump are provided with shutdown controls so that the various component parts will be protected against overheating.

The pump is equipped with single mechanical seals, and protection against seal failure is obtained by a float switch which will shut the unit down when an excessive amount of fluid drains to the sump. A combustible-gas analyzer for the continuous sampling of the atmosphere in the pump room is being installed to shut the station down in

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the event an explosive mixture should develop. This equipment is considered necessary to provide a means of detecting small leaks which might develop in the pump room. These small leaks, although not of sufficient magnitude to cause their detection by a pressure drop, could result in the creation of a hazard or the loss of a considerable amount of product over an extended period of time.

The operation of any of these protective devices sounds the alarm at the control console, and drops a flag on an annunciator panel at the remote station. Correction of the trouble and manual reset are required before the remote station can again be started if any of the annunciator flags are dropped.

Pressure control . . . Fig. 5 is an interior view of the pump room. The pneumatically-operated pump-discharge motor valve and controller may be seen in the background. Of particular interest is the dual-pen single-pilot pressure controller, which has a single pilot which may be actuated by either the suction or discharge-pump pressures. This instrument controls the motor valve on the pump discharge.

A timing device permits the pump to start and come up to normal operating speed with the motor valve closed. The discharge-set pointer is then slowly advanced from its initial setting, which is equal to the adjusted station bypass pressure of about 400 psi. at the time of startup, to the operating pressure-set point which is not allowed to exceed 1,050 psi.

The timing device consists of a small electric-clock motor installed in the upper left-hand portion of the instrument case, and this device starts when the electrically operated discharge valve in the station manifold clears its port. The clock motor, through a system of cams and levers, advances the discharge-set pointer over a timed interval, which is variable from 5 to 15 minutes. This permits the pump to come on the line by a gradual opening of the discharge motor valve without overloading the motor which drives the pump, and without overpressuring the pipe line during the time that the high pump-case pressure, caused by the high suction pressure at the time of starting, is being lowered.

After the pump is on the line, the pressure controller provides throttling action, as required, to maintain preset suction and discharge pressures. An arrangement is made to return the discharge-set pointer to the starting position when the station is shut down. The pump-discharge motor valve is of the air-to-open type, and is held in the closed position during shutdown periods by a solenoid valve in the instrument air-supply line.

The position of the solenoid valve always coincides with the position of the manifold discharge valve. Pressure switches are installed on the pump-suction and station-discharge lines, and operate to shut the station down if safe operating limits are exceeded. The suction switch also provides a means of shutting the station down in the event of an emergency which might arise during a period when communication between the stations had been lost.

Emergency shutdown is accomplished by overriding the pneumatic controller and reducing flow through the pipe line to a point at which the pump-suction pressure will fall below a preset minimum pressure of 10 psi.

Telemetering . . . Standard telemetering units collect the data concerning pressures and power consumption at the remote station, and furnish timed impulses which key the respective tone units in the radio cabinet. These tones are transmitted to the receiving units at the initial station. The length of the signals received during each 15-section interval is proportional to the full-scale reading of the instruments, and this results in the transmitted data being recorded accurately on the control console instruments.

The wattmeter which transmits the power consumption is located in the door of the main starter cabinet, and the suction and discharge-pressure transmitters are located in explosion-proof enclosures adjacent to the pump building.

Additional stations . . . In addition to the station just described, two other remotely controlled booster stations are being operated on a 6-in. pipe line which now has a total of four stations spaced over its length. The two booster stations are controlled from an intermediate pump station by its regular complement of station operators. By reason of the radio-transmitted information available to the operator at all times, the operation of all the stations can be synchronized in a manner which maintains the maximum throughput of the pipe line.

The operation and control of the booster stations are essentially the same as the system employed on the 8-in. pipe line. The principal difference is that a hydraulically operated pump-discharge control valve is used rather than the pneumatic controls previously described. This method makes use of hydraulic pilots for suction and discharge-pump pressure control. A timing device, which consists of an accumulator and a variable orifice, accomplishes the same throttling action as the dual-pen controller when the stations are being started.

Projected features . . . Many unforeseen difficulties developed during initial operation of the stations. One of the most serious was caused by dust accumulations in the many relays in both the tone units and sequence controls. This problem will be completely eliminated in the future by the installation of a small blower to pressurize the control and radio cabinets with a supply of filtered air. This problem emphasizes the need for using dustproof equipment under the adverse conditions often encountered in the field.

Personnel requirements . . . The remote booster station is designed for normally unattended operation, and could operate for an extended period of time without attendance. However, a policy has been established which provides for one man to be on duty 40 hours per week to maintain the station equipment and grounds. This attendance exceeds the minimum requirement; but, because of the distance which separates the remote station from other installations, it is not economical to provide the transportation which would be required for lesser attendance.

The station normally operates for periods of 72 hours without attendance. The operation and control of the remote station do not require additional personnel at the initial station.

Advantages . . . Experience indicates that the selection of microwave has been justified, as maintenance cost has been low and circuit availability has been approximately 98 per cent. This service factor is excellent in view of th fact that standby radio equipment is not provided, and the time out of service includes the total outage from all causes—including tube failures and control-equipment faults.

Efficiency is constantly improving as a preventive-maintenance routine is developed. Maintenance of the microwave equipment requires only a small portion of an electrician's time, and does not interfere with the performance of his other duties.

The additional equipment required to permit operation of the station by remote control is estimated to have increased the total station cost 15 per cent over what it would have been if manual controls requiring full attendance had been installed. Savings in labor cost alone have paid out this additional investment in nine months of operation.

The use of microwave as a means of remote-station control has proved satisfactory in this instance, and has made possible a considerable increase in the capacity of the pipe line with a minimum increase in operating costs.

Use of High-Speed Computing Machines

(Continued from page 261)

punched cards, which means that recalling a number may take from 0.4 to 10 seconds. Although the C.P.C. is very slow in terms of the giant high-speed computers, it is much faster than desk machines. Furthermore, it has been demonstrated to be usable for numerous reservoir-engineering problems.

Whirlwind . . . The Massachusetts Institute of Technology computer, Whirlwind, is truly high speed. It is about 1,000 times faster than the C.P.C. Whirlwind is being used by the M.I.T. Department of Industrial Cooperation to study methods of solving reservoir-engineering problems. This work has been carried out as a part of a program to study the utility of the machine for industrial problems. Carter Oil Co. has been assisting in this work. This machine is still being improved; and, by next year, should be able to illustrate how reservoir-engineering problems can be solved by high-speed techniques.

The phenomenal speed of Whirlwind and its kind has resulted from the development of special electronic circuits and devices to permit the storage and rapid access of numbers. Whirlwind uses for its memory cathode-ray tubes something like the screen in a very small television set. These are hooked up in such a way that the face of each tube is divided into a grid of 512, 1,024, or 2,048 squares.

When a sweeping electron beam puts a spot, or a charge, in one of the squares, a number is stored there and can be picked up by the electron beam at some short time later. Instructions or a complete code can be placed in this cathode-ray tube storage. As long as this storage is not overcrowded with numbers and instructions, calculations can be carried out at a rate of about 10,000 four-digit numbers per second. In a few months Whirlwind should have available a much larger auxiliary memory based on the principle of storage on a magnetic cylinder. This should eliminate most of the difficulties so far encountered in working with this machine.

Other digital computers . . . There are are a large number of universities and commercial organizations working on several different types of computers. A partial list of these is given in Table 2, together with descriptive remarks and information regarding the state of development.

Analog-type computers . . . The petroleum industry has already had some experience in perfecting special electrical circuits to solve very complex problems. The electric or electrolytic model[2,3] has been effectively used in the gas-cylinder problems. The hydrocarbon-composition analyzer was developed to study mass spectrograms and to solve vaporization-equilibrium problems[4] involving multicomponent hydrocarbons. The oil-pool analyzer[5] was developed to solve water-drive problems. Each of these devices has been based upon the flow of electricity in a network and the corresponding mathematical expression of this behavior.

Reservoir-Engineering Problems and High-Speed Computing

An indication of what these computing machines can do and how this should concern an oil-producing company can best be understood by a discussion of several important problems, and by a comparison of new computing techniques with conventional practice.

Natural depletion . . . In producing a normal natural-depletion reservoir the problems usually concern how much oil can be produced and what kind of gas-production behavior to expect. Very few pools are now being produced by natural depletion without at least some comparative consideration of the economics of fluid injection. This means that, for comparative purposes, management and frequently state regulatory bodies, wish to know what recoveries to expect by natural depletion.

Approximate prediction of behavior by natural depletion is very simple.[5,6] The reservoir is regarded as a large tank from which oil, gas, and water are produced in such a way that pressures and saturations are equalized throughout the pool at all times. The energy for this production is in the gas dissolved in the oil.

Information on the pressure-volume behavior of the gas and oil in the reservoir rock is obtained from laboratory data. Two basic relationships are set up. A material balance or an equation relating the material withdrawn from the reservoir to expansion of reservoir fluids is stated as follows (if no water influx is involved):

$$\text{Expansion of reservoir fluids} = \text{withdrawals of gas and oil} \quad (1)$$

A second equation defines the gas-oil ratio:

$$\text{Gas-oil ratio} = \text{solution gas-oil ratio} + \text{gas-liquid mobility ratio} \quad (2)$$

These two equations must then be solved simultaneously for oil produced and pressure. The results are predictions of gas-oil ratio and pressure vs. cumulative oil recovery. Decline in daily potential can also be estimated. A calculation of this type can be done in about 6 days by an engineer who is familiar with the work. It can be done using C.P.C. in ½ day or less.

This time saving alone would not be very important, but recently reservoir engineers have found increasing need for more reliable methods for natural depletion predictions. The most important causes of the deviations of actual pool behavior from that predicted by the foregoing equations are: (1) stratification and other heterogeneities in the reservoir; and (2) gravity drainage. A simplified correction for stratification can be made by assuming that the reservoir is made up of layers which are isolated from each other but which produce into a common system of wells. Fig. 2 shows how much change in predicted behavior this change in method makes.

Computations allowing for stratifications are fairly simple to carry out but increase the calculation time from 6 to 18 days on desk machines. This problem can be solved in 12 hours with the I.B.M. card-programed calculator. Whirlwind could probable do it in 5 minutes.

Natural depletion with gravity drainage . . . Gravity drainage is not usually very important for small reservoirs undergoing natural depletion, but in the case of a large reservoir, gravity effects may be very important and may entirely dominate the behavior of a pool undergoing natural depletion. So far no established method has been published for dealing with the combination natural depletion-gravity drainage problem. Recently three workable although admittedly cumbersome methods of coping with this problem have been developed.* Fig. 3 shows the difference the force of gravity makes in the natural depletion behavior of one large pool having a fairly gentle dip (6°). It would seem fairly obvious that for this problem inclusion of a gravity drainage term would be necessary, and would warrant the large amount of computation required.

A complicated analysis of this problem designed to eliminate most of the obvious assumptions, increases the work by a large factor. In solving the gravity drainage problem, 250,000 calculations had to be made in a somewhat simplified version. This, together with necessary entries, required 350 man days

*This work has been done by several people in the research laboratory of Carter Oil Co. aided by Dr. John von Neumann of the Institute for Advanced Study.

of desk machine work for 50 months of the prediction. This is almost too much calculation to consider feasible by use of desk machines.

So far it has been impractical for more than two people to work on the straight calculation part of a complex reservoir problem at the same time. Hence, the total time necessary to obtain a workable solution even for one set of conditions would be almost a year. Usually several comparative solutions are needed; hence, the time elapsed to get a reliable answer might be several years. This is so long that a decision would probably have to be made before the answer could be obtained.

It is the solution of this type of problem that should produce a real payoff with high-speed machines. In the case of the example just discussed two different types of solutions have been put in a form that could be handled by Whirlwind, the high-speed computer at M.I.T. This machine, while very fast, is at present not sufficiently versatile to cope efficiently with a problem of the complexity found in the natural depletion gravity drainage problem. However, solutions by two different methods have been found. The time necessary to obtain such a solution is 20 hours as compared with several years of desk machine work.

Water drive . . . In the early 1930's water-drive behavior was little understood. Those engineers who did try to predict the behavior of pools known to have active water drives used a simple expression in which the amount of water coming into the pool was assumed to be proportional to the drop in pressure at the pool. Such an expression would hold for 6 months or a year, but the constant of proportionality was continually changing.

In 1934 research people at Humble Oil & Refining Co. and Gulf Oil Corp. independently[7,8] introduced the concept that the flow of water into petroleum reservoirs would be described by a simple linear partial differential equation referred to by mathematicians as the "heat equation." Various solutions of the water-drive problems were published by several authors. Each solution was designed to cope with more and more complex reservoir problems.

One of the most elaborate and complicated of these was described by the author in an A.I.M.E. meeting February 1942,[9] in connection with a water-drive problem in Magnolia pool. The complete solution of this problem required over 6 man-months of actual computing work.

It appeared at that time that mathematical methods could be developed that would be sufficiently elaborate to handle almost any degree of complexity of pool configuration or behavior. However, the time necessary to obtain a solution seemed to be getting comparable with the time that the prediction could be extended into the future. About this time the development of a high-speed computing machine of the analog type was started and resulted in an oil-pool analyzer[1,10] which is now used by a number of companies to predict water-drive behavior. With this machine, problems of such complexity as had never before been formulated were easy to solve.

By way of comparison, the Magnolia reservoir problem, which required more than 6 man-months of desk machine and graphical work, was solved with the oil-pool analyzer in a matter of 1 to 2 days. Furthermore, the solution provided by the analyzer is much more reliable and provides more directly usable information for reservoir engineering studies.

Water flooding . . . Studies on water flooding have grown in complexity along with other reservoir-engineering problems. The simplest approach to predictions of water-flooding behavior is to assume that the water will move from the injection well to the producing well, sweeping out oil in a flood pattern. Engineers have usually assumed that the area of this flood pattern is between 70 and 75 per cent of the total area. Calculations based on this approach are fairly simple and do not justify the use of high-speed calculating machines. However, recent laboratory work, theoretical studies, and field observations have indicated that flooding water invades nearly all of the reservoir having appreciable permeability rather than being restricted to a limited area.

Instead of a recovery factor applicable to the area as a whole, it now appears that there is a functional relationship involving relative permeability, viscosities, and stratification that relate oil recovery to water injection. This functional relationship is exceedingly complicated and, while it is known that it can be solved, actual solutions which account for all important parameters would require something of the order of over 100 million calculations for a reasonable variety of operating conditions. At the present time only a few machines are sufficiently large and flexible to take care of this problem as it should be handled; although developments in progress may result in several "production models."

It is possible to obtain an approximate solution that is an improvement over the very simple treatment now commonly employed. This intermediate treatment of the water-flooding problem is similar to the handling given the dissolved-gas-drive problem in which due consideration of stratification is taken. In carrying out this solution the formation to be flooded is divided into separate strata having differences in permeability. The amounts of water that each stratum will take is computed from relative permeability and specific permeability data. The total water intake and oil production are composited from these separate calculations.

Fig. 4 indicates the oil production vs. water-injection curves calculated on the basis of such a compositing technique as compared with the same type of curve obtainable by a very simple calculation in which the corrections are not made for stratification. This calculation allowing for stratification required 10 days for a fairly large problem. (The pool in question has 15 subdivisions and contain about 2 billion barrels of oil in place.) This type of problem is ideal for handling with the I.B.M. card-programed calculator. The more complete solution would require a Whirlwind.

Gas injection . . . These operations fall broadly into two classifications, viz.: (1) a distributed system of injection wells usually in a uniform pattern such as a five-spot or a sunflower pattern; and (2) gas injection to enhance a gas-cap drive and to take advantage of a natural tendency for gravity segregation. The distributed gas-injection problem may be studied and predictions can be made by the same type of technique used for the distributed water-flooding problem.

The gas-cap drive problem is different. When gas is injected into the top of a reservoir, allowance has to be made for gravity drainage. Buckley and Leverett[11] introduced a very effective method for dealing with a problem of this type in which it was possible to assume that all of the gas would be injected at one end of the linear column and that all of the oil would be withdrawn at the other end. This method is easy to carry out, particularly if later simplications introduced by Welge[12] are employed. However, in most reservoirs the gas cannot be injected exactly at one end of the reservoir and the oil is certainly not withdrawn entirely from the other end. Therefore, the practical utility of this technique for prediction work is somewhat limited.

A more elaborate scheme in which the reservoir is broken into sections

has been developed; but here again, the detailed numerical work is greatly increased. The desk-machine calculation time necessary to solve the problem by this method, assuming that the pool has to be divided into as many as five zones, amounts to about 120 man-days for three operating programs. This has been considerably reduced by precalculation of tables using the C.P.C. A machine like Whirlwind could do the entire job in an hour or two.

Vapor-liquid equilibrium calculations . . . During the last year or so several organizations have applied the I.B.M. 604 electronic calculating punch to vapor-liquid equilibrium calculations. Some of this work has been summed up in a discussion of the use of computing machines in chemical engineering by the American Chemical Society.[4] As indicated above, this problem was first machine calculated using an analog computer. The problem can also be solved easily with a digital computer. Humble recently made a study in which it was indicated that the manual calculation took 27 man-weeks as compared with 0.67 week for the digital using the I.B.M. 604.

Why We Do So Much Computing

An explanation of why we need to do so much computing seems reasonably straightforward. Petroleum reservoirs are heterogeneous systems about which there is never quite enough information to form an entirely clear picture. In the early stages of development this picture changes as every new well is drilled. The reservoir yields additional information revealing its character with every day's production. No two reservoirs are alike and no two pools are ever handled in the same way. Add to this general complexity the multiplicity of ownership and diversity of financial interests in most pools, and it is apparent that a lot of computation is necessary.

An answer to the question of whether this technological work is worth its cost is more complex. If the reservoir engineering groups could make infallible predictions or even if they were as reliable as, for example, refining engineers, there would be no question about the necessity of the most elaborate engineering study possible for every pool. Reservoir engineering as a technology is just beginning to crystallize. This is a condition that produces many arguments and differences of opinion among the experts. It allows to fluorish the nontechnical guesser, who at times, will be found right when the engineers will be found wrong. In spite of this difficulty, the managements of most producing companies realize the need for reservoir engineering and see the profit to be obtained from improving the technology.

The reservoir engineering of today leans heavily upon theoretical methods. Much effort is put forth by research organizations to obtain data on how reservoirs behave, in order to demonstrate the validity of theories for calculation of predicted reservoir behavior, and to check the validity of evaluation techniques.

The reason for this approach may be illustrated by a comparison with refining technology. In the refining industry a new development such as a cat cracker can be installed in Montana with reasonable assurance that it will work about the same as the first one built in New Jersey. If there are minor deviations, successive tests can be made on the completed installation and modifications made as indicated.

In the crude-oil production industry, it is practically impossible to make tests with the pool as a whole. For example, it is certainly not possible to operate a pressure-maintenance project at three different pressures so that the optimum pressure can be chosen. Theoretical predictions of the optimum have to be used.

Answer to problem . . . The answer to this problem is the development of theories of pool operation and behavior sufficiently comprehensive to cope with any degree of reservoir complexity and any set of observed or proposed operating conditions. The validity of a number of these theories has been checked by comparison with the behavior of pools in which operating conditions have been simple enough to obtain a clear-cut comparison.

The engineers have demonstrated to management that the application of accepted theories to most problems is better than guessing, and that the applications of these theories are getting better. The correct solution of any of the problems discussed in the foregoing section may be worth a sum measured in millions of dollars. The following may illustrate how much it may be worth to carry out a complex computing job.

Shuler-Jones pool, located in southwestern Arkansas, was discovered in September 1937. A statutory regulation controlled the drilling to one well per 20 acres. The drilling was practically completed within about 2 years and the pool was in full regulated production by 1940. In spite of attempts to control production rate the reservoir pressure dropped rapidly and the gas-oil ratio was rising. By mid-1940 it was apparent that this would be a depletion reservoir and that the recovery would be something between 30 and 35 per cent. This would amount to not more than 35 million barrels of oil recovery.

Very extensive studies of Shuler-Jones pool were made. As an indication of the amount of money the operators felt willing to spend for information and improved technology, about one-quarter of a million dollars was spent for obtaining cores and core analyses. The engineering work for each of the major companies could have been measured in man-years. As a result of this large amount of engineering and associated computing, a decision was reached in 1941 to commence gas injection and to carry out an elaborate program of well control. The result was a sharp change in reservoir behavior.

Fig. 5 shows how the gas-injection program halted the pressure decline and how the well-control program retarded the increase in gas-oil ratio. This elaborate program of reservoir control has resulted already in producing an additional 25 million barrels of oil. Furthermore, the operators have been able to produce at a steady high rate of production for the 15-year life of the pool. The value of this engineering study, both from the standpoint of current income and ultimate recovery, is probably more than 100 times its cost. Each of the examples of reservoir studies shown above could be illustrated by an example of a money-making reduction to practice.

Planning for High-Speed Computing

A look into the future might be of interest. A number of oil companies have obtained or will soon install the card-programed calculator. This seems to be an intermediate step that is considerably in advance of nonmechanized computing. This equipment also offers an opportunity to experiment with methods of processing large volumes of data. Thus, at the same time that the theoretical work is being improved and advanced, it may also be possible to carry forward empirical and statistical methods.

The most profitable computing equipment probably lies far beyond the C.P.C. Larger memory, certainly more than 1,000 numbers of eight digits, is desirable. About two orders of magnitude greater speed seem to be needed. The first company to come out with a "production model" in this class is Remington-Rand with its "Univac." Two of these have been delivered to the Government and are in operation. I.B.M. is in production with its "defense calculator" and should be making deliveries early next year.

University of Illinois has made a computer, "Ordvac," of which the labo-

ratory model built at the Institute for Advanced Study was the prototype. Thus, it seems likely that oil companies will be able to buy or rent large-scale high-speed general-purpose computers almost as soon as they could get into position to make use of such equipment.

Effective use of a high-speed computer will probably require several years after the decision has been reached to buy or rent the equipment. Experience with the C.P.C. indicates that a staff of three or four people must be extensively trained to prepare problems and run them. The larger models may require more.

In the foregoing description of reservoir problems, it was indicated that some of these required as much as 100 million arithmetic operations for solution. Extensive use of these machines may show that many times this complexity is desired. At the present time the data obtained from individual wells are composited and smoothed to give a simple understandable picture of the reservoir as a whole. This is necessary because present methods of handling data and present habits of visualization are such that the engineer is barely able to deal with the complexity now recognizable. As the engineers become more used to handling elaborate detail, it will certainly be advisable to set the problems up with due consideration for the maximum amount of heterogensity recognizable. Thus, a very big and fast machine may ultimately be required to solve oil-producing problems.

TABLE 2

Calculator, Builder and Location

Whirlwind*—M.I.T., M.I.T.

I.A.S. digital* computer—Institute for Advanced Study, Princeton, N. J.

Ordvac*—University of Illinois, Aberdeen Proving Grounds.

University of Illinois*—University of Illinois, University of Illinois.

Edvac*—Moore School of Electrical Engineering, University of Pennsylvania, Aberdeen Proving Grounds.

Univac*—Remington-Rand.

Circle computer—Hogan Laboratories, Westinghouse Electric Corp. and John Hopkins University.

Elecom-100 and 120—Electronic Computer Corp., New York.

I.B.M. defense calculator* (701 elect. data processing mach.)—International Business Machines.

I.B.M. S.S.E.C.—International Business Machines, New York City.

Cadac—Computer Res. Corp., Hawthorne, Calif., M.I.T., Air Force Lab., Cambridge.

Burroughs Lab computer—Burroughs Adding Machine Co.

O.N.R. relay computer—Office of Naval Research, George Washington University.

A.B.C. (automatic binary computer)—Air Force Cambridge Research Center, Cambridge, Mass.

*Very high speed. Machines similar in speed and general utility.

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What's the Outlook for Oil-Country Tubular Goods?

(Continued from page 263)

provement of material-handling equipment, thereby lessening down time on open-hearth and blast-furnace repairs, removal of production-line bottlenecks—such as enlarging of blooming-mill and round-mill facilities—as well as improvement in threading, coupling, and testing facilities.

These improvements could add approximately 400,000 tons of tube-making capacity. This capacity will be added gradually as improvements are made, but the first effects of this program should be felt during the fourth quarter of 1953 and during the year 1954.

The question can be raised as to why the steel industry has delayed expanding its tube-making capacity when it has been quite obvious that there has been a shortage of tube-making capacity for several years.

When the steel industry undertook its expansion program in 1950, it was natural that it would increase its steel-making capacities in the items where the demand seemed to be steadiest, and the return for dollar invested in capital equipment would be the greatest. Since 1954, the advance in the price of tubular goods has been less than that for other steel products.

A look at Fig. 1 shows how the number of wells drilled annually has varied. It is my opinion that the drop in the rate of drilling in 1942 and 1943 can be directly attributed to the fact that the United States had a 34 per cent reserve productive capacity at the start of World War II; and, as a result, steel was channeled into other products which did not have the reserve capacity enjoyed by the oil industry.

In addition to the foregoing production from domestic mills the supply picture will be augmented by tubular production from foreign mills, which have a theoretical rated capacity of 450,000 tons. These mills have never been able to reach this rated capacity because, for the most part, they are not fully integrated mills and depend for their rounds on the availability of scrap as the European ores from which steel is made are of a high phosphorous content and only 20 per cent of the ores are suitable for making rounds of tube-piercing quality.

To augment the supply available from foreign sources, the A.P.I. at the mid-year standardization meeting in Denver gave tentative approval to the manufacture of tubular goods by use of the killed-deoxidized-basic-Bessemer or Thomas process of making steel when agreed upon between the purchaser and the manufacturer. The use of this process will permit the use of high-phosphorous ores and should materially assist foreign mills to increase the quantity of tubular goods they are able to manufacture.

As in the past several years, there will be an indeterminate amount of used tubular goods and the substitution of line pipe in shallow wells. The aggregate of this tonnage is relatively small.

So much for the supply picture—a picture which can be established within relatively narrow limits.

As R. L. Foree of PAD so aptly put it, the demand picture certainly requires the use of a crystal ball; and, although PAD admits the use of a crystal ball, certainly its calculations have been within the ball park. There was considerable doubt that the oil industry could drill 43,400 wells in a year, granting that tubular goods could be made available. The question was asked: Where will the rigs come from to drill this number of wells? The oil industry has answered this question by their proved ability to drill wells during 1951 and the first 6 months of 1952.

In fact, PAD's first calculations were on the low side.

The significant figure here is the fact that although wells drilled are 10 per cent ahead of 1951, a record year, the footage drilled is 18 per cent ahead of 1951, indicating that the industry may be drilling to a greater depth sooner than anticipated as this increase exceeds the rate at which the average well depth has been increasing. This increase has been approximately 100 ft. per year (see Fig. 2).

A demand for heavier weights of pipe and better grades of steel is indicated. This can certainly be substantiated by the experience of California operators. Several years ago the future of oil production in California was far from encouraging, and California was almost written off as a state in which future oil discoveries would be small and insignificant. Let us look at the record. With increased drilling, production in California has climbed to 980,000 bbl. per day; and with addition of currently shut-in production at Elk Hills, condensate production and currently shut-in production from marginal wells, the state total could reach 1,250,000 bbl.

Continued drilling activity will be necessary to maintain this production rate and with recent new discoveries in California in the Eocene and Sespe sands, an entirely new concept of where oil may be found in California has developed. These wells will be deep wells—10,000 ft. plus—and will again require heavier weights of pipe and better grades of steel. The situation which exists in California is duplicated in other sections of the country.

The Williston basin in the Dakotas, offshore activities in the Gulf of Mexico and California, and Canadian operations, all offer prospects for increased use of tubular goods.

PAD has predicted the need for oil-country tubular goods into 1953 with projected figures assuming continuation of expanded program into 1954 and 1955. I cannot find any general disagreement with the program as outlined for the remainder of 1952 and 1953, but some people are quite skeptical and believe that the crystal ball became a bit cloudy when the figures for 1954 and 1955 were compiled. To establish the authenticity of the demand picture, it is necessary to take a look at how this picture was developed. In March 1951, a survey was made by PAD to determine the oil requirements of the country to meet both military and civilian needs.

This initial survey was later supplemented by surveys of the National Petroleum Council and a more comprehensive procedure for forecasting crude-oil production capacity was developed by PAD. Fig. 3 was developed from these surveys. In this chart the decline rate for a factor (F) of 1 is 8.9 per cent per year. While productive capacity has increased in relation to wells drilled, the country's reserve productive capacity has not been increased to a safe level, as demand for petroleum products have been constantly increasing as shown in Fig. 4.

Quoting from the summary of this procedure:

"A procedure has been developed for analyzing past trends of crude-oil productive capacity in order to make possible forecasting of future capacity as affected by the rate of drilling. Essentially, the analysis consists in the calculation of the contribution to productive capacity of the wells completed during the past years.

"The decline in productive capacity of the wells producting at the beginning of a given year is estimated and the contribution of the wells completed during the year is calculated from the difference between the actual total productive capacity at the end of the year and the estimated capacity of the old wells at the date. Future capacity is estimated by utilizing the trends developed in this manner together with historical trends in the ratio of dry holes to total completions . . .

"The following conclusions seem justified in the light of the work done in this study:

"1. The proposed method of analysis gives reasonably consistent results over the 7-year period studied.

"2. Forecasts made by this procedure are in substantial agreement with the PAD forecasts of March 1951, and with the findings of the NPC Committee on Crude-Oil Availability.

"3. The sum of individual area analyses agree very closely with the analysis of the entire United States as a unit.

"4. Forecasts made in this manner should be reliable for 2 or 3 years into the future and should furnish useful approximations of a few additional years.

"The basic assumption underlying the work described above is that the trends of discovery and development which have existed in the past will continue into the foreseeable future. The rising trend in productive capacity may eventually end and a period of static or declining capacity may ensue, but there is no evidence to indicate that this time is approaching. Oil is still being found in new geologic provinces, and other large provinces are as yet practically untested. Furthermore, large potential reserves undoubtedly exist even in the more highly developed areas at depths which have in the past been beyond reach of the drill. As drilling technique improves it will be possible to discover and develop these deeper reserves.

"Probably the most significant factor in present-day discoveries, however, is the increasing application of subsurface geology within the highly developed areas. This method gains in usefulness as more wells are drilled in an area, because each well drilled furnishes geological information which may provide the clue needed to unravel some obscure structural or stratigraphic problem. For this reason, it is inconceivable that discoveries based on subsurface geology will suddenly cease.

"Thus it is likely that any change in the trend of discoveries is likely to be a gradual one, particularly since the productive capacity of the United States is being supported to a continually greater extent by the discovery of large numbers of small accumulations rather than the finding of major fields.

"It is, therefore, felt that the methods used are basically sound, although it is realized that there is some uncertainty in any forecast of future production in an industry as rapidly changing as the petroleum industry. It is believed that forecasts made in this manner should be reliable for 2 or 3 years into the future and should furnish useful approximations for a few years beyond this period.

"The method is essentially a statistical one and is primarily applicable to large areas containing large numbers of pools. When the procedure is applied to the United States as a whole, the various uncertainties involved in the data tend to compensate because of the large size of the statistical sample. For instance, unexpected discoveries are made from time to time in previously unproductive geologic provinces, but since such discoveries have contributed to past trends, a projection of trends for the United States as a whole will tend to allow for these occurrences."

The demand for wells to be drilled is predicted on the continuing increasing demand for oil. At no time during the past 10 years has domestic production equaled the demand. Imports at an increasing amount have filled the gap between demand and domestic production (see Fig. 4).

World-wide production averaged 11,698,645 bbl. at the end of 1951, with daily crude runs to stills totaling 11,871,099 bbl.

Certainly the trend for the future is for increased use of the products of petroleum; and, with the cooperation of the steel industry, the ingenuity and resourcefulness of the petroleum industry, we propose to get the job done.

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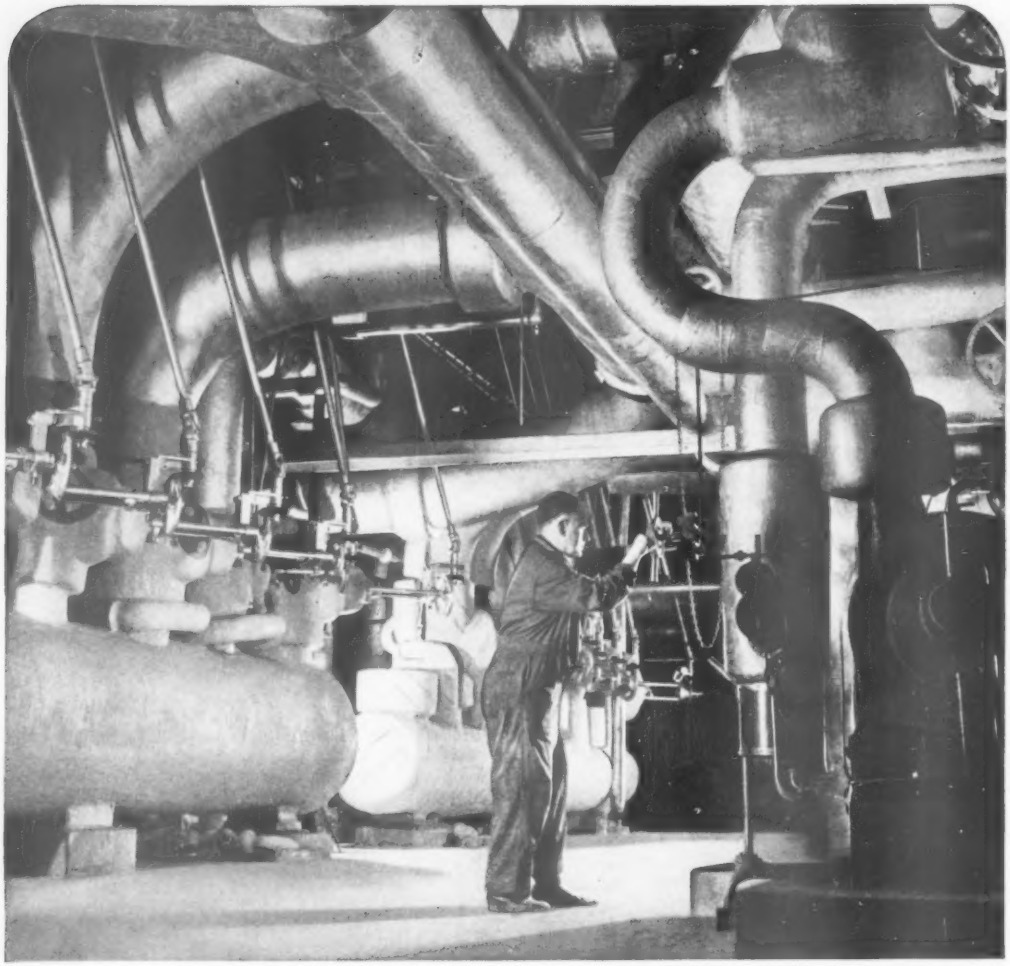

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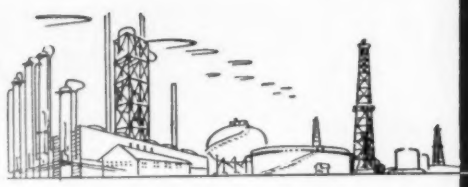

THE JOURNAL'S WEEKLY
Engineering Reference
SECTION

No. 30

FANS AND BLOWERS:

Part 11—How to Use Fan Laws In Figuring Fan Performance

by M. Van Winkle*

FRICTION-LOSS calculations for fan ducts are continued from the preceding installment.

48-in. by 48-in. section:

$$D_H \text{ (48-in. by 48-in.)} = 4\left[\frac{(48)(48)}{144} \Big/ \frac{(4)(48)}{12}\right] = 4 \text{ ft.}$$

$$v \text{ (48-in.)} = 1{,}500/60 = 25 \text{ ft./sec.}$$

$$\rho = 0.75 \text{ lb./cu. ft.}$$

$$L \text{ (elbow)} = (10)(4) = 40 \text{ ft.}$$

$$L \text{ (duct)} = 4 + 20 = 24 \text{ ft.}$$

$$L \text{ (total)} = 64 \text{ ft.}$$

$$Re = dv\rho/\mu = \frac{(25)(4)(0.075)}{(0.000672)(0.0179)} = 62{,}400$$

$$p_{f4} \text{ (48-in. by 48-in.)} = [0.00540 + 0.397/(62{,}400)^{0.3}] \times (64/4)(0.075/32.2)(25^2/2)$$

$$= 0.225 \text{ lb./sq. ft.}$$

$$= 0.225/5.2 = 0.0434 \text{ in. } H_2O$$

Estimation method:

$$p_{f4} = p_v \text{ for } 40D_H$$

$$p_v = (1{,}500/4{,}004)^2 = 0.141 \text{ in. } H_2O$$

$$40D_H = 40 \times 4 = 160 \text{ ft.}$$

$$L_e = 64 \text{ ft.}$$

$$p_{f4} = \frac{64}{160}(0.141) = 0.565 \text{ in. } H_2O$$

Total frictional loss:

$$p_f = p_{fe} + p_{fe} + p_{fe} + p_{f4}$$

$$= 0.0087 + 0.0114 + 0.103 + 0.214 + 0.0434$$

$$= 0.3805 \text{ in. } H_2O$$

*Professor of chemical engineering, University of Texas.

Total fan pressure:

$$p_w = p_f + \Delta p_s + \Delta p_v$$

$$= 0.3805 + 0.544 + 0$$

$$= 0.9245 \text{ in. } H_2O$$

Fan Laws

In drawing up the specifications for a particular fan or blower application it is necessary for the engineer to evaluate quantitatively both fan and system characteristics. The performance of all fans of all types is governed by a set of so-called "fan laws."

Fan laws . . . These are expressed as relations between certain variables when other fan operating variables are maintained constant, and may be shown as follows:

A. Constant: Gas density, system characteristics.

1. Varying fan speed:

$$Q = aS; \quad P = a'S^2; \quad W = a''S^3.$$

2. Varying fan diameter. For constant tip speed:

$$Q = bD^2; \quad P = \text{a constant}; \quad S = b'(1/D); \quad W = b''D^2.$$

3. For constant r.p.m.:

$$Q = cD^3; \quad P = c'D^2; \quad S_t = c''D; \quad W = c'''D^5.$$

B. Constant: Fan speed, fan diameter, quantity delivered system characteristics.

1. Varying gas density:

$$Q = \text{a constant}; \quad P = d\rho; \quad W = d''\rho.$$

C. Constant: Pressure, fan diameter, system characteristics:

$$Q = e\frac{1}{\rho^{0.5}}; \quad S = e'\frac{1}{\rho^{0.5}}; \quad W = e''\frac{1}{\rho^{0.5}}.$$

D. Constant: Weight of gas, fan diameter, system characteristics for variable-speed fan:

$$Q = f(1/\rho); \quad P = f'(1/\rho); \quad S = f''(1/\rho); \quad W = f'''(1/\rho^2).$$

The meaning of the symbols is given as follows:

- Q = capacity or delivery, cu. ft. per minute
- P = pressure
- W = horsepower input
- S = fan speed, r.p.m.
- D = fan diameter
- S_t = peripheral or tip speed, feet per minute
- ρ = gas density, lb. per cu. ft.
- ρ = gas density, lb. per cu. ft.
- a, b, c, d, e, f, and the primes are proportionality constants.

MORE ON PUMPS . . .

Beginning with the issue of December 1, a new series will be featured on this page dealing with the subject of Centrifugal Pumps. Calculation of suction and discharge heads, and determination of pump horsepower and net positive suction head will be taken up.

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McCullough Back-Off Service Is Fast

1

All free pipe can be removed from the well before it has a chance to stick further up the hole. A common occurrence if action is not taken immediately. The McCullough Magna-Tector and String Shot locate the lowest free point and loosen all free pipe in a matter of hours compared to the days needed by other methods. For example: Drill pipe was stuck at 10,600 feet. The Magna-Tector located the stuck point just above the drill collars. A String Shot loosened the first joint above the stuck point and pipe was recovered without damage. Total time was three hours and 55 minutes.

All Free Pipe Recovered In Two Easy Steps

2

First, the Magna-Tector locates the stuck point—within inches—within minutes. Second, the String Shot loosens the first joint above the stuck point. All free pipe is recovered at one time. For example: An operator estimated the stuck point of his drill pipe to be at about 4200 feet. However, the Magna-Tector located the stuck point at 5362 feet. The String Shot loosened the first free joint at 5350 feet. All free pipe was recovered at one time. Actually, the operator received a bonus of 1150 feet of pipe he didn't expect to recover so easily and subsequent fishing operations were simplified and speeded.

Magna-Tector Saves Fishing Jobs

3

The Magna-Tector not only locates the stuck point in drill pipe, casing, or tubing, but many times indicates the sticking medium, and in some cases working and/or spotting oil in the tight place indicated by the Magna-Tector, has freed the pipe. This is a fairly common occurrence and has eliminated many fishing jobs. For example: Drill pipe was stuck at 8340 feet. The Magna-Tector located the stuck point at 6540 feet. However, the Magna-Tector indicated that the pipe was frictionally held by compacted shale or sand. Working the drill pipe loosened the string, freeing it deeper and deeper down the well until all the drill pipe was free. The Magna-Tector and immediate action saved the operator many hundreds of dollars.

Unusual Jobs Accomplished

4

The McCullough Magna-Tector and String Shot save the operator untold hours of rig time because of their ability to perform the tough, unusual jobs. Jobs such as back-off operations through the restricted I. D. of fishing tools, production packers, etc.—operations in high angle holes—operations under excessive pressure and temperature—and many others. For example: An operator's tubing was stuck in 7" casing. The Magna-Tector revealed that the packer was stuck. A fifteen foot String Shot, 200 grains of explosive per foot, was placed through the body of packer and detonated. Packer came loose immediately. There was no damage to tubing or packer.

No Substitute For Experience

5

Over 10,000 jobs, successfully completed, make up McCullough's backlog of experience in back-off operations. Our equipment is the most efficient and dependable available. Our Servicemen have wider experience in back-off operations than any other group of men in the oil industry. They are specialists—specialists in getting pipe out of the hole in the fastest possible time at the least possible cost—specialists in saving you time, money, and pipe.

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3.—More Service From Industrial Hose

by J. A. Muller*

PART 2 of this series was presented in **Modern Drilling** last week. Discussed there were details of hose construction, the factors which should be considered in hose selection, and important points to be followed in maintenance of the hose.

Avoid sunlight . . . Although antioxidants are put into all modern hose covers, oxidation remains the principal enemy of rubber hose. Strong, direct sunlight speeds up oxidation and should be avoided. A particularly bad offender is ozone (O_3) which occurs to some extent at high altitudes and in harmful concentrations near high-voltage equipment.

Oil and grease on a hose are bad unless the hose is specifically designated as oil-resistant.

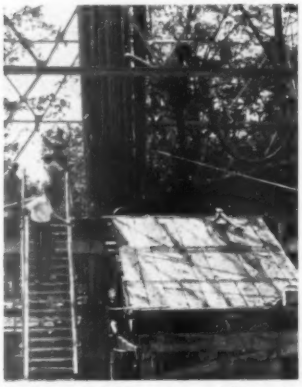
Harsh abrasion and punctures should, of course, be avoided. It is generally good practice to cut out a badly worn spot before an actual failure occurs and install a new coupling.

Take care to keep hose away from falling rocks. In quarries, mines, construction jobs where falling material is a normal occurrence, hose should be removed to a safe area before blasting or should be protected by a guard. At road crossings hose should be carried overhead on a scaffolding or underground by conduits.

When not in use, hose should be stored inside out of the sun, flat on the floor rolled in coils of large diameter to avoid kinking. The rolls should not be so large that the weight of the coils will crush and weaken the bottom layers of hose.

For temporary storage hose can be hung on wall brackets. Adequate support in more than one place is required to prevent sharp bends. Hooks or other supports should be thick enough so that the hose is not cut or subjected to excessive distortion at the point of contact.

*Executive engineer, Thermoid Co., Trenton, N. J.



RUBBER HOSE used on drilling rigs should be hung to avoid kinks and bends.

MORE ON . . .
Care and Maintenance Of Oil-Field Chains*

Dangers of worn sprockets . . . Chain cannot be efficient or durable if used with worn or faulty sprockets. It is, therefore, important to inspect sprockets occasionally for wear and alignment.

1. Be sure shafts are set parallel and level in rigidly supported bearings.

2. Sprockets must be mounted squarely and securely on their shafts.

3. **Never run new chain on worn sprockets.** When new chain is installed, never run it over sprockets with worn, "hooked" teeth. Hooked teeth tend to grab or hold the chain to the sprocket, an action which no chain can long stand.

4. **Never run badly worn chain on new sprockets.** Just as worn sprockets hurt good chain, worn chain will cause premature wear on new sprockets. If your chain is "riding up" on the sprocket teeth and not seating properly, chances are that it's worn and the pitch is elongated. Once the pitch is elongated, sprocket life is appreciably shortened.

5. **Sprocket reversal.** Sprockets, if not too badly worn, can, in some cases, be reversed on the shaft and the opposite surfaces of the teeth used.

*Courtesy, Chain Belt Co.

High-speed drives . . . (use SAE 30 oil for this class of drive). Chains operating at high speeds should be completely enclosed in an oil-tight case. It is important that the proper oil level be maintained. The lower strand of the chain should just dip into the oil when chain is running.

Excess oil will cause churning and heating.

Extremely high-speed drives . . . (use SAE 40 oil for this class of drive). Chains running at extremely high speeds require special equipment for proper lubrication.

The standard oil-tight case and oil bath lubrication is not satisfactory as the oil becomes turbulent and never reaches the working parts of the chain.

Proper lubrication of extremely high-speed drives requires a force-feed circulating pump system. The pump keeps the oil circulating and discharging continuously to the inside of the chain so that it is thrown outward through the chain.

How to cut chain . . . a. Place the chain in the chain vise where cutting is required and tighten vise. Be sure that the vise is closed sufficiently to hold the rollers firmly.

b. With a blunt end punch and hammer, strike one pin and then the other on the same pin link. Repeat until the outside plate is free.

c. Remove the freed side plate.

d. The pin link will now fall out, or can be removed by hand, and all that is necessary is to remove the chain from the vise, add any necessary connecting links and offset links, and chain is ready for use.

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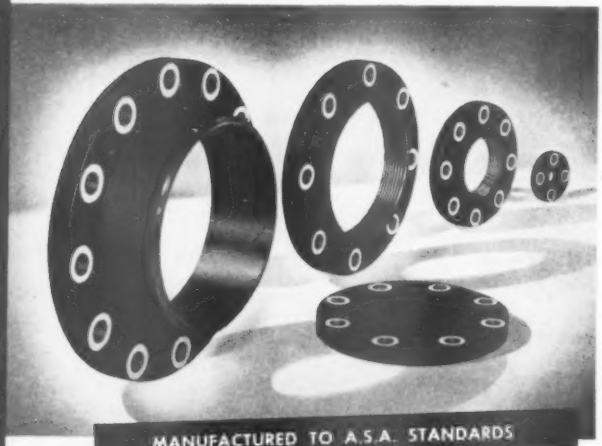

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No. 145

REFINER'S NOTEBOOK

ELECTRICAL INSTALLATIONS—5

Sealing Systems

by B. Z. Segall*

IN general, mild steel, cast iron, or malleable iron will be used for the conduit, fittings, enclosures, etc. Certain installations, however, will require other types of metal. For example, aluminum should be used for petrochemical installations where ammonium nitrate is handled since this attacks steel and zinc.

For other conditions, special brass, bronze, or copper conduits and boxes may be required. Special paints or coatings may also be used. However, use of special paints presents quite an installation and maintenance problem.

Sealing

The wiring system in a hazardous location is only as safe as its sealing system. Without seals in the conduit any explosion within the system would be transmitted throughout the conduit and would also seek to escape through any and all joints in the system. Because it is impossible to keep the enclosures gastight or vaportight, there will in general always be gas or vapor present in all the conduits, cases, and enclosures. It is, therefore, very undesirable to have the explosion in any part of the wiring system transmitted directly to other parts of the electrical system.

Pressure piling . . . Another serious effect results from such unsealed wiring systems. This is known as precompression of the unexploded gases or vapors.

If the wiring system is left unsealed, the initial explosion in any part of the system will cause the gas or vapor in other parts to be subjected to pressures above atmospheric pressure. This building up of pressure, or "pressure piling" as it is usually termed, builds up as the primary explosion transmits itself to the adjacent gases and vapors in the conduits and enclosures.

There will be set off successive secondary explosions with an increasing pressure piling. The results of exploding this precompressed gas or vapor is many times greater in destructive power than the explosion of the gas or vapor at atmospheric pressure. Proper sealing thus sectionalizes the wiring system and definitely eliminates secondary explosions and pressure piling. Fig. 1 illustrates this condition.

In Class I, Division 1 areas the code sets up three general sealing requirements. The first requires seals in each conduit run entering an enclosure which contains any device or apparatus producing arcs, sparks, or high temperatures. In other words, switches, circuit breakers, motor starters, push buttons, fuses, relays, resistors, etc., would require sealing of the conduit runs extended to the enclosures housing these devices. The seals are required to be placed **as close as practicable** to the enclosure but must not exceed 18 in. in distance. Fig. 2 schematically illustrates these rules.

*Consulting engineer, New Orleans.

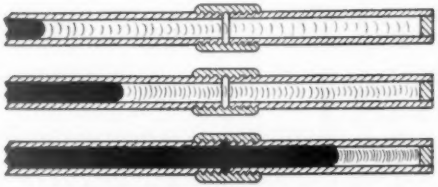

Fig. 1—Pressure piling . . . showing three stages in the progress of flame through a conduit. Unignited gas is precompressed ahead of the flame by expansion of the burning gas. The plug at right end of conduit might represent a seal, or the conduit might end in an enclosure. Each coupling would be a source of leakage, even if it were possible to make all joints of each enclosure absolutely gastight. (Illustration courtesy Crouse-Hinds Co.)

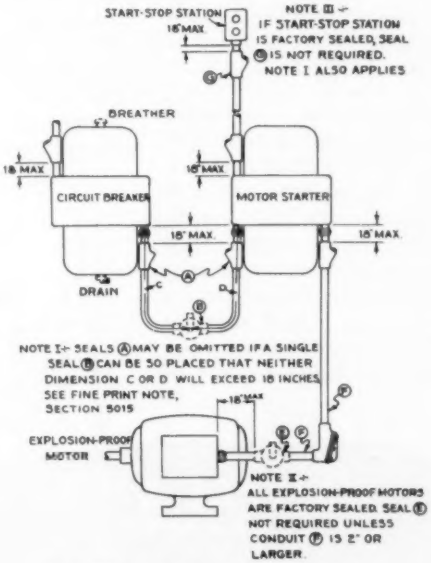
START-STOP STATION
18" MAX
NOTE III — IF START-STOP STATION IS FACTORY SEALED, SEAL (S) IS NOT REQUIRED. NOTE I ALSO APPLIES
BREATHER
18" MAX
18" MAX
CIRCUIT BREAKER
MOTOR STARTER
18" MAX
18" MAX
DRAIN
NOTE I — SEALS (A) MAY BE OMITTED IF A SINGLE SEAL (B) CAN BE SO PLACED THAT NEITHER DIMENSION C OR D WILL EXCEED 18 INCHES. SEE FINE PRINT NOTE, SECTION 5015
18" MAX
EXPLOSION-PROOF MOTOR
NOTE II — ALL EXPLOSION-PROOF MOTORS ARE FACTORY SEALED. SEAL (E) NOT REQUIRED UNLESS CONDUIT (F) IS 2" OR LARGER.

Fig. 2—Class I, Division 1, sealing requirements.

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Part 12 of a series

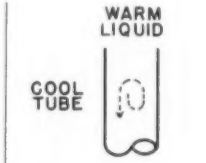
by Dr. B. E. Lauer, Head, Department of Chemical Engineering, University of Colorado

h_f HEAT TRANSFER

COEFFICIENT of HEAT TRANSFER through FILM between INSIDE SURFACE of COOL TUBE and WARM LIQUID

Tube Position: Vertical

Liquid Movement: Natural Convection.



EQUATION:

$$h_f = 0.128\left[\frac{k^3\rho^2 C\beta g\,\Delta t}{\mu}\right]^{\frac{1}{3}}$$

TERMINOLOGY:

h_f - Film coefficient of heat transfer, BTU/hr. sq. ft. °F.

K - Thermal conductivity of liquid at t_f, BTU/hr. sq. ft. °F./ft.

L - Length of vertical tube, ft.

ρ - Density of liquid at t_f, lb./cu. ft.

g - Acceleration of gravity. 4.17×10^8 ft./hr.^{2}

β - Coefficient of volumetric expansion of liquid at t_f.

Δt - Temperature difference between wall and liquid, °F.

μ - Viscosity of liquid at t_f, lb./ft. hr.

C - Specific heat of liquid at constant pressure in BTU/lb. °F.

t_f - Film temperature, assumed as arithmetic average of wall temperature and bulk liquid temperature, °F.

LIMITATIONS:

Although confirmed only for water and air, this equation is the best now available for the warming or cooling of fluids at low velocities (below 0.1 ft./sec.) in vertical tubes.

SOURCES OF DATA:

For physical constants for use in above equation see Chemical Engineers' Handbook, J. H. Perry (1948).

for ρ see pp. 130-148, 175-195, 1583.
μ see pp. 370-374, 1198, 1696.
β see pp. 200-202, 1676.
k see pp. 459-461, 1303, 1697.
C see pp. 225-235, 297, 1588, 1696.

REFERENCES:

1. Applied Heat Transmission, J. H. Stoever, p. 60, (1941).

2. Chemical Engineers' Handbook, J. H. Perry, p. 471.

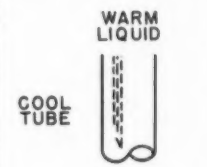
E 2 a

COEFFICIENT of HEAT TRANSFER through FILM between INSIDE SURFACE of COOL TUBE and WARM LIQUID

Tube Position: Vertical

Liquid Movement: Streamline Flow

Special Consideration: Water or liquids of low viscosity.



EQUATION:

$$h_f = 1.78\frac{k}{D}\left[\left(\frac{\mu}{\mu_f}\right)^{\frac{1}{3}}(1+0.015Z^{\frac{1}{3}})\right]\left[\frac{4wC}{\pi kL}\right]^{\frac{1}{3}}$$

where $Z = \left(\frac{\beta\,\Delta t\,D^3\rho^2 g}{\mu^2}\right)$

TERMINOLOGY:

h_f - Heat transfer coefficient BTU/hr. sq. ft. °F.

k - Thermal conductivity, BTU/hr. sq. ft. °F./ft.

D - Diameter of pipe, in feet.

μ - Viscosity at bulk temperature of the stream, lbs/hr. ft.; μ_f is evaluated at t_f, μ_s at t_s.

w - Mass rate of flow, lbs./hr.

C - Specific heat at constant pressure, BTU/lb.°F.

L - Heated length of pipe, in ft.

β - Coefficient of volumetric expansion,

Δt - Temperature difference between bulk temperature of fluid and t_s, °F.

ρ - Density, lbs./cu. ft. at t_f.

g - Acceleration due to gravity, 4.17×10^8 ft./hr.

t_s - Temperature of surface, °F.

t_f - Average film temperature, °F $t_f = 0.5\,(t_s + t)$

t - Bulk liquid temperature, °F.

LIMITATIONS: For liquid flowing downward in tube.

SIMPLIFIED EQUATIONS: For flow of water below 0.1 ft./sec.

$h_f = 0.49\,t\,(\Delta t)^{\frac{1}{3}}$ upward flow.
$h_f = 0.42\,t\,(\Delta t)^{\frac{1}{3}}$ downward flow.

SOURCES OF DATA: For physical constants see Chemical Engineers' Handbook, J. H. Perry (1948).

for ρ -- see pp. 130-148, 175-195, 1583.
μ -- see pp. 370-374, 1198, 1696.
β -- see pp. 200-202, 1676.
k -- see pp. 459-461, 1303, 1697.
C -- see pp. 225-235, 297, 1588, 1696.

REFERENCES:

1. R. C. Martinelli, C. J. Southwell, etal, Trans. Am. Inst. Chem. Engr., 38, 433 (1942).

2. Heat Transmission, W. H. McAdams, p. 191.

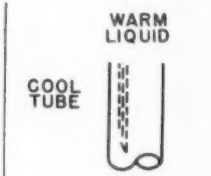
E 2 b (1) (a)

COEFFICIENT of HEAT TRANSFER through FILM between INSIDE SURFACE of COOL TUBE and WARM LIQUID

Tube Position: Vertical

Liquid Movement: Streamline Flow

Special Consideration: Liquids of high viscosity.



EQUATION:

$$h_f = 2.0\,\frac{k}{D}\left[\frac{wC}{kL}\right]^{\frac{1}{3}}\left[\frac{\mu}{\mu_s}\right]^{0.14}$$

TERMINOLOGY:

h_f - Film coefficient of heat transfer, BTU/hr. sq. ft. °F.

k - Thermal conductivity of liquid, BTU/hr. sq. ft. °F./ft.

D - Inside diameter of tube, ft.

w - Mass rate of flow, lbs./hr./tube.

C - Specific heat of liquid, BTU/lb. °F.

L - Length of tube, ft.

μ - Viscosity at bulk temperature, lb./ft. hr.

μ_s - Viscosity at temperature of surface, lb/ft. hr.

V - Velocity, ft./hr.

ρ - Density of liquid, lb./cu. ft.

LIMITATIONS:

Reynolds number ($DV\rho/\mu$) must be below 2100.

SOURCES OF DATA:

For physical constants for use in above equation see Chemical Engineers' Handbook - J. H. Perry, (1948).

for ρ -- see pp. 130-148, 175-195, 1583.
μ -- see pp. 370-374, 1198, 1696.
k -- see pp. 459-461, 1303, 1697.
C -- see pp. 225-235, 297, 1588, 1696.

REFERENCES:

1. Chemical Engineers' Handbook, J. H. Perry, p. 471.

2. Sieder and Tate (Ind. Eng. Chem.) p. 28, 1429 (1936).

3. Colburn and Hougen (Ind. Eng. Chem.) p. 22, 522, (1930).

E 2 b (1) (b)

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Pipe-Line Construction

HERE is The Oil and Gas Journal's current report on expansion activity of the pipe-line industry. This biweekly Journal feature is prepared from reports received directly from owner and contracting companies.

The listing includes projects under construction, contracted, and planned. Projects not yet under construction or contracted are indicated by a • opposite the particular company listing.

Crude-Oil Pipe Lines

• **California-Oregon Pipe Line System**—103 miles, 6-in., proposed, Crescent City, Calif., to Medford, Oregon.

• **Cities Service Pipe Line Co.**—64 miles, 18-in., planned, Sour Lake, Tex., to Lake Charles, La. Completion date April 1953.

• **Continental Pipe Line Co.**—217 miles, 12-in., planned, Wichita Falls, Tex., to Ponca City, Okla. Completion date 12-25-52.

Under way, Wichita Falls, to near Cox City, Okla. R. H. Fulton. 12-25-52.

Under way, Perry, Okla., to Three Sands, Okla. R. H. Fulton. 12-25-52.

Under way, Near Cox City, Okla., to Continental's Oklahoma City pump station. Western Construction Co. 12-25-52.

• **Cooperative Refinery Association.** — 48 miles, 6-in., planned, Phillipsburg, Kans., to Holdredge, Neb. Begin 3-53.

• **Gulf Refining Co.** — 80 miles, 24-in., under way Midland to Colorado City, Tex., Anderson Bros.

22 miles, 10-in., under way, Wortham to Corsicana, Tex., Anderson Bros.

• **Humble Pipe Line Co.**—71 miles, 16-18-in., planned, East Texas to Louisiana-Texas border. (30 miles of 16 in., and 41 miles of 18-in.) Completion date 10-53.

• **Interstate Oil Pipe Line Co.**—22 miles, 18-in., planned, Texas to Shreveport, La.

68 miles, 16-in., planned, Raceland to Anchorage, La. Begin 4-53.

137.6 miles, 22-in., planned, Shreveport to Baton Rouge.

• **Magnolia Pipe Line Co.**—29 miles, 8-in., planned, Midland County, Texas area.

Malco Refineries, Inc.—60 miles, 4-in., under way, Pettigrew, Tocito field to Hospah field (San Juan basin, New Mexico).

• **Pan American Pipe Line Co.**—27 miles, 26-in., begin 11-52. Genoa to Texas City, Tex. Completion date 3-53.

47 miles 16-in., begin 12-52, Arden Station in Irion County to Eldorado Station in Schleicher County, Texas. 3-53.

Pasotex Pipe Line Co.—195 miles, 8-in., under way, El Paso to Wink, Tex. McVean & Barlow, contractor. Completion date 1-1-53.

• **Phillips Pipe Line Co.**—45 miles, 12-in., planned, Rancho system to Sweeny, Tex. 3-53.

Phillips Pipe Line Co.—50 miles, 14-in., under way, looping in Duro and Rankin, Tex. area.

• **Progress Pacific Pipeline Co.** — 1,100 miles, 24-in., planned, Odessa, Tex., to Los Angeles Harbor, Calif.

Rancho Pipe Line System.—455 miles, 24-in., under way, McCamey to Houston, Tex. Completion date late 1952. (Joint project with Sinclair Pipe Line Co., Pan American Pipe Line Co., Tidewater Pipe Line Co., Nantucket Pipe Line Co., Phillips Pipe Line Co., and Ashland Pipe Line Co. with Shell Pipe Line Corp. handling construction and operation.)

McCamey to Cedar Valley near Austin, Tex. Anderson Bros. Corp. A. Kilgore, spreadman at Menard, Tex.

(Segment 1)—Austin to Shell's Deer Park Refinery (Houston area). Oklahoma Pipe Line Constructors.

(Spread 1)—Brazos River west to Austin, Houston Contracting Co.

• **Roosevelt Oil & Refining Corp.** — 22 miles, 4 and 6-in., planned, St. Helens to Norwich, Mich.

• **Service Pipe Line Co.**—16-in., planned, Bowie, Tex., to Drumright, Okla.

30 miles, 6-in., Knox and Haskell counties, Texas.

29 miles, 4-6-8-in., proposed, Natrona County, Wyoming.

170 miles, 12-in., proposed, Tioga to Williston, N. D.

Sinclair Pipe Line Co.—674 miles, 22-24-in., under way, Cushing, Okla., to East Chicago, Ind. Completion date 1952.

Section 1, Drumright-Cushing, Okla., area to Humboldt, Kans. O. R. Burden Construction Co.

(Spread 1) Caney to Humboldt, Kans. A. B. Haynes, superintendent at Chanute, Kans.

(Spread 2) Cushing, Okla., to Caney, Kans. Floyd Lewis, spreadman at Hominy, Okla.

Humboldt, Kans., to Salisbury, Mo. R. H. Fulton & Co., contractor. M. L. Boyd and Jerry Nash, spreadmen.

Salisbury, Mo., to Forest City, Ill. O. R. Burden, contractor.

22-in. Forest City, Ill., to East Chicago, Ind., Britton Bros., contractor.

• **Sterling Pipe Line System.**—53 miles, 12-in., planned, Sterling, Colo., to connection with Platte Pipe Line at Gurley, Neb. (Includes 20 miles, 10-in., main line; 35 miles, 8-in., branch lines). Joint venture comprising Toronto Pipe Line Co., Shell Pipe Line Corp., and Texas Pipe Line Co.

• **Sun Pipe Line Co.**—34 miles, 8-in., planned, Jameson to Colorado City, Tex.

20 miles, 6-in., planned, Claytonville to Colorado City, Tex.

• **Texas-Empire Pipe Line Co.**—30 miles, 18-in., planned, Wilmington to Lockport, Ill.

• **Texas-New Mexico Pipe Line Co.**—48 miles, 8-in., planned, from Lovington, N. M.

• **Toronto Pipe Line Co.**—100 miles, 6-10-12-in., planned, Merino, Colo., to Gurley, Neb.

• **West Coast Pipeline Co.**—960 miles, 20-22-in., planned, Synder, Tex., to Norwalk, Calif.

West Texas Gulf Pipe Line Co.—466 miles, 20-26-in., under way, Colorado City to Sour Lake, Tex. Anderson Bros. Completion date 1-1-53.

(1) Contracted, Middle section from Wortham toward Sour Lake, Tex.

(2) Henderson County to Longview, Tex.

Products Pipe Lines

• **Bell Oil & Gas Co.**—150 miles, 6-8-in., planned, Ardmore to Drumright, Okla. Completion date 6-1-53.

Buckeye Pipe Line Co.—370 miles, 8-12-16-in., under way, Linden, N. J., via Allentown, Pa., to Auburn, Syracuse, Waterloo, and Rochester, N. Y. (Sections divided as follows: 75 miles, 16-in., 218 miles, 12-in., 77 miles, 8-in.). Completion of 16-in., 1952, balance 1953.

• **Coastal Products Pipe Line Co.**—260

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WATE-KOTE is the high-strength, high-density weighting material developed by Rosson-Richards to lick the toughest weighting problems at minimum cost. WATE-KOTE is not only the heaviest weighting material of its type yet developed, but is tough enough to take a lot of punishment during laying operations.

WATE-KOTE is uniformly reinforced with embedded steel wires to provide an adherent material almost as strong as the pipe itself — and many times heavier.

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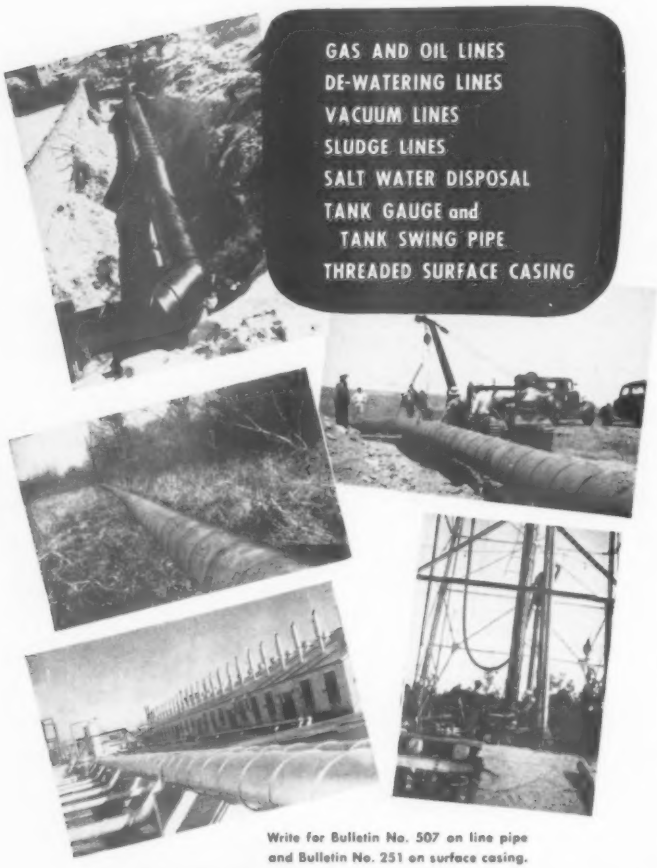

Write for Bulletin No. 507 on line pipe and Bulletin No. 251 on surface casing.

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miles, 20-in., proposed, Houston to Baton Rouge.

• **Continental Pipe Line Co.**—600 miles, 8-in., planned, Billings, Mont., to Spokane, Wash.

• **Harbor Products System**—86 miles, 16-in., planned, Philadelphia to Trembley Point, N. J. (Joint ownership of Sinclair Pipe Line Co., Gulf Oil Corp., and Texas Co.)

Indiana Farm Bureau Cooperative Association, Inc.—180 miles, 8-in., under way, Mt. Vernon to Indianapolis, Ind. R. B. Potashnick, contractor.

70 miles, 4-in., under way, Indianapolis to Peru, Ind. R. B. Potashnick, contractor.

Ohio Oil Co.—255 miles, 8-10-in., East St. Louis, Ill., to Indianapolis. Conyes Const. Completion date 11-52.

Phillips Petroleum Co.—50 miles, 8-in., under way, Goldsmith to Spraberry, Tex. McVean & Barlow. Completion date 12-52.

54 miles, 6-in., planned, Goldsmith to Borger, Tex.

52 miles, 10-in., planned, Shell's Brookshire system to Sweeny, Tex.

Phillips Pipe Line Co.—35 miles, 6-in., planned, Okmulgee, Okla., to Tulsa. Completion date 12-52.

Pioneer Pipe Line Co.—(Continental Pipe Line Co. and Sinclair Pipe Line Co.). 310 miles, 8-in., under way, Sinclair, Wyo., to Salt Lake City, Utah.

• **Progress Pacific Pipe Line Co.**—900 miles, 10-in., proposed, California to West Texas.

Salt Lake Pipe Line Co.—330 miles, 8-in., contracted, Salt Lake City to Boise, Idaho. Macco Corp., and Engineers, Ltd.

140 miles, 8-in., Pasco to Spokane, Wash. Completion date 6-53.

Shell Oil Co.—565 miles, 8-14-in., under way, Wood River via East Chicago to Detroit. R. B. Potashnick, contractor on Wood River—E. Chicago portion of project.

Shell Pipe Line Co.—266 miles, 24-in. under way, McCamey to Cedar Valley, Tex. Anderson Bros. Corp.

• **Sinclair Pipe Line Co.**—90 miles, 12-in., planned Sinco to Port Arthur, Tex.

• **Standard Oil Co. (Ind.).**—316 miles, 12-in., proposed, Sugar Creek refinery to Dubuque, Iowa. Completion date 1-1-53.

243 miles, 10-12-in., proposed, Whiting, Ind., to River Rouge, Mich.

Sun Pipe Line Co.—110 miles, 8-in., under way, Fostoria to Hudson, Ohio.

• **United States Pipe Line Co.**—1,600 miles, 14-22-24-in., proposed, Port Neches, Tex., to Newark, N. J. (Includes 560 miles, 25-in., Port Neches to Jackson, Tenn.; 120 miles, 14-in., lateral to Paducah, Ky., and 1,045 to Newark).

• **Wolverine Pipe Line System**—200 miles, 14-in., planned, Chicago to Toledo and Detroit. (Joint ownership of Shell, Texas, and Cities Service).

Natural-Gas Pipe Lines

• **Allied Gas Co.**—24 miles, 6⅝-in., proposed, McLean to Champaign County, Illinois.

• **Arkansas-Missouri Power Co.**—140 miles, 2 to 10-in., planned, St. Francis River, Clay County, Arkansas, to near Campbell, Mo.

• **Associated Natural Gas Co.**—88 miles, Missouri.

• **Carolina Natural Gas Corp.**—185 miles, 2-12-in., proposed, lateral lines off Transcontinental in North and South Carolina.

• **Chattahoochee Natural Gas Co.**—70 miles, proposed, Floyd County, Georgia, to Dalton, Ga.

Cities Service Gas Co.—179 miles, 4-30-in., gathering system in vicinity of Ulysses, Kans.

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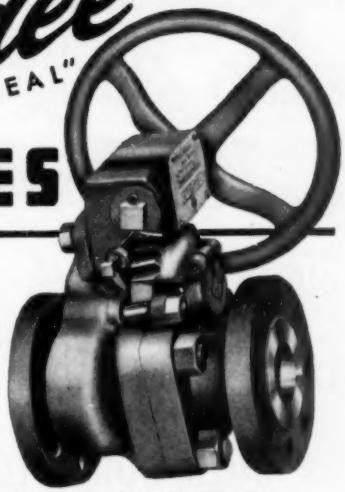

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15 miles, 20-in., Craig County, Oklahoma, to Lawrence County, Missouri.

Cities Service Gas Co.—21 miles, 26-in., planned, Franklin and Anderson counties, Kansas.

• **Coast Counties Gas & Electric Co.**—40 miles, 3, 4, and 8-in., planned. Coast and Valley region, California.

Colorado Interstate Gas Co.—250 miles, 20-in., under way, Kit Carson, Colo., to Amarillo, Tex. R .H. Fulton & Co., contractor. Jerry Nash spreadman at Lamar, Colo.

Pueblo County to Fowler, Colo.

• **Commonwealth Natural Gas Corp.**—537 miles, 20-in., proposed, West Bend, Ky., to Norfolk, Va.

• **Cumberland and Allegheny Gas Co.**—31 miles, 12-in., proposed, Garrett County, Md., to Keyser, W. Va.

Dow Chemical Co.—70 miles, various sizes, Midland, Saginaw, and Bay City, Mich. Mahoney Contracting Co., contractor. Ralph Bucher, spreadman at Midland.

• **East Tennessee Natural Gas Co.**—172 miles, 22-in., planned, Greenbrier to Oak Ridge, Tenn.

100 miles, 16-in., proposed, Knoxville to Kingsport, Tenn.

• **El Paso Natural Gas Co.**—822 miles, proposed, Permian Basin, N. M., and West Texas.

181 miles, proposed, field transmission lines.

97 miles, proposed, main transmission line on San Juan Basin, N. M. to California.

El Paso Natural Gas Co.—133 miles, 30-in., under way, Kermit, Tex., to Colorado River, Company Crews. Completion date, December 1952.

•**Fredericksburg Natural Gas Co.**—29 miles, 3-4-in., planned, Fredericksburg, Va., area.

• **Georgia Gas Co.**—32 miles, 4½-in., proposed, Bogart to Gainesville, Ga.

• **Glacier Gas Co.**—285 miles, 20-in., proposed, Kalispell, Mont., to Spokane, Wash.

120 miles, 16-in., proposed, Spokane to Hanford, Wash.

91 miles, 8⅝-in., proposed, Spokane to Lewiston, Idaho.

130 miles, 12¾-in., proposed, Spokane to International boundary at Trail, British Columbia.

• **Gulf Interstate Gas Co.**—860 miles, 30-in., proposed, Acadia Parish, La., to Boyd County, Ky.

329 miles, 12 to 24-in., proposed. Laterals off Acadia Parish, Louisiana, to Boyd County, Kentucky, line.

• **Home Gas Co.**—32 miles, 12-in., planned, Breesport to Union Center, N. Y.

17 miles, 12-in., proposed, loops from Hancock to Sanford, N. .

46 miles, 12-in., under way, Tioga and Broome counties, New York. H. L. Gentry Const.

• **Hope Natural Gas Co.**—33 miles, 8-10-12-in., planned, Wyoming County, West Virginia, south to Buchanan County, Virginia.

Iowa-Illinois Gas & Electric Co.—41 miles, 10-in., planned, Washington County to Cedar Rapids, Iowa.

• **Kansas-Nebraska Natural Gas Co., Inc.**—179 miles, planned, Kansas and Nebraska.

18 miles, 6-8-in., planned, McCook, Neb., south. Completion date 1952.

54 miles, 4-6-in., planned, Neligh to Hartington, Neb. Completion date 1953.

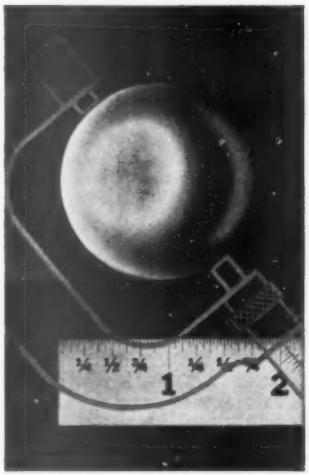
20 miles, 12-in., planned, Atwood to near Oakley, Kans. Completion date 1952

Kansas-Nebraska Natural Gas Co., Inc.—49 miles, 10-in., under way, Ogallala to North Platte, Neb. Engineering Const. Co. Completion date 1952.

• **Kansas Power & Light Co.**—27 miles,

ONLY A BALL

has { one dimension / one surface



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20-in., planned, Pratt, Kans., to Calista compressor station.

28 miles, 12-16-in., planned, north of Kansas to Meade County gas field.

• **Lake Shore Pipe Line Co.**—75 miles, 10¾-in., under way, T.G.T. connection at Cochranton, Pa., to Fairport via Ashtabula, Ohio.

• **Lone Star Gas Co.**—100 miles, proposed, storage fields to the Dallas-Fort Worth area.

35 miles, 12-in., proposed, southeastern Schleicher County. 12-52.

Lone Star Gas Co.—70 miles, 20-in., under way, Garvin County, Oklahoma, to Clay County, Texas. 12-52.

• **Manufacturers Gas Light & Heat Co.**—40 miles, proposed, Allegheny, Washington, and Beaver counties, Pennsylvania.

213 miles, 3 to 26-in., proposed, various points on system in Pennsylvania, West Virginia, and Ohio.

• **Michigan Gas Storage Co.**—30 miles, 26-in., planned, Laingsburg Junction north.

• **Midsouth Gas Co.**—191 miles, planned, Helena to Palestine, Ark.

• **Mississippi River Fuel Corp.**—98 miles, 16 and 18-in., planned, feeder line from Lincoln Parish, Louisiana, to Waskom field, Harrison County, Texas.

40 miles, 18-in., planned, Dubach to Perryville, La.

Missouri Central Gas Co.—25 miles, 6-in., contracted, Moberly to Macon, Mo. L. R. Young Const. Co.

• **Missouri Public Service Co.**—136 miles, 8-10-in., proposed, New Franklin to Trenton, Mo.

• **Montana Power Co.**—52 miles, 16-in., planned, Canada-Montana border to Cut Bank, Mont.

• **Morganfield Natural Gas Co.**—31 miles, 4-6-in., planned, through Sturgis, Providence, Clay, Diamond, Wheatcroft, and Sullivan, Ky.

Natural Gas Storage Co. of Illinois.—43 miles, 30-in., under way, Kankakee and Iroquois counties, Illinois. Ray L. Smith and Son. Completion date 11-30-52.

• **Nevada Natural Gas Pipe Line Co.**—114 miles, 10-in., planned, Topock, Ariz., to Las Vegas, Nev.

• **New River Gas Co.**—50 miles, planned, Summers to Monroe counties, West Virginia, to Narrows and Dublin, W. Va.

• **New York State Electric and Gas Co.**—59 miles, 8-10-24-in., proposed, Oneonta and Norwich to DeRuyter, N. Y.

New York State Natural Gas Corp.—104 miles, 14, 16, 20-in., under way, looping on Westmoreland, Armstrong, and Tioga counties, Pennsylvania. (Includes 17 miles, 16-in., in Potter County, Pennsylvania, and 21 miles 14-in., replacement in Line No. 507, New York.)

Utica to Amsterdam, N. Y. (to begin at completion of Zelienople). Williams-Austin. Howard Bauer, superintendent. Completion in 90 days.

Angelica to Rossburg, N. Y. (begin at completion of Cayuta-Ithaca). Williams-Austin. Howard Bauer, superintendent. Completion in 45 days.

Colesburg Junction to Sabinsville, Pa. (begin at completion of Angelica job). Williams-Austin. Howard Bauer, superintendent.

21 miles, Columbiana and Stark counties, Ohio.

• **New York State Natural Gas Co.**—95 miles, 16-20-in., planned, Clinton County to Armstrong County, Pennsylvania.

(Section 1) 16-in., Clinton County, Pennsylvania.

(Section 2) 20-in., Armstrong County, Pennsylvania, begin 1953.

29 miles, 20-in., under way, looping from Tonkin Station to Kittanning, Pa. Williams-Austin Co. Completion date 12-15-52.

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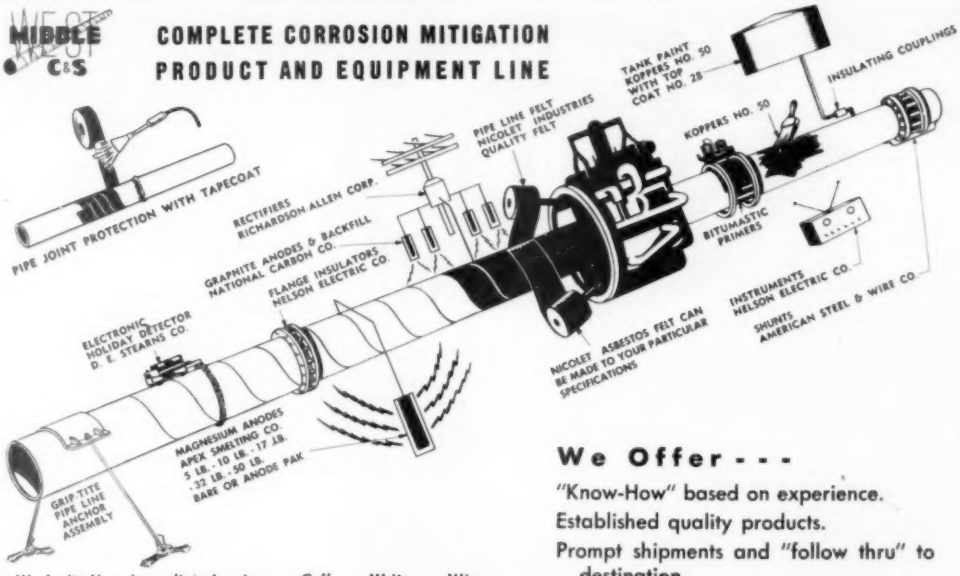
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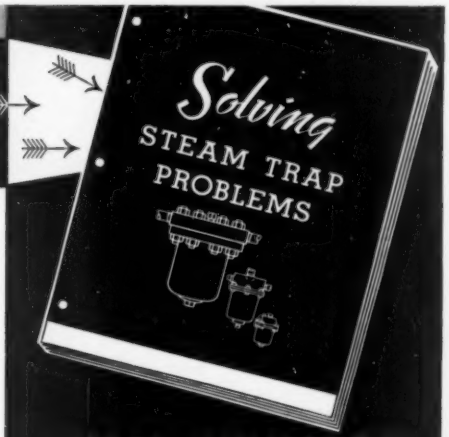

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• **Northern Natural Gas Co.**—580 miles, proposed, Kansas, Texas, Oklahoma, and Nebraska loops.

210 miles, 26-in., planned, five loops in Texas-Oklahoma area, two in Kansas, and two in Nebraska.

400 miles, 24-in., proposed, Emerson, Manitoba south to Red River Valley through Fergus Falls on to St. Paul, Minn.

102 miles, planned, extension.

Northern Natural Gas Co.—140 miles, 4-6-8-in., under way, south of Rolla, Kans., to Guymon, Okla. Reese Bros. Const. Co. E. H. Reese, spreadman at Hugoton, Kans.

• **Northern Indiana Fuel & Light Co.**—13 miles, 8-in., proposed, Edgerton to Auburn, Ind.

• **Northwest Natural Gas Co.**—750 miles, planned, Washington, Oregon, and Idaho.

24-in., Eastport, Idaho, to Monroe, Wash.

18-in., Monroe to International boundary near Lynden, Wash.

22-in., Monroe to near Seattle, Wash.

20-in., Seattle to Portland, Ore.

• **Ohio Fuel Gas Co.**—31 miles, 20-in., planned, Licking County to Richland County, Ohio.

22 miles, 16-in., planned, Dayton, Troy, Piqua, and Sidney, Ohio.

23 miles, 16-20-in., planned, Wellington to Elyria, Ohio; 16 miles, 20-in., planned, Benton Station to Crawford Station; 18 miles, 20-in., Crawford Station to near Columbus; 16 miles, 16-in., planned, Berlin to Sandusky, Ohio.

74 miles, 3 to 20-in., planned, Hocking, Knox, and Ashland counties, Ohio.

47 miles, 20-in., planned, Benton Township, Hocking County, to Columbus, Ohio.

61 miles, planned, northern and southwestern Ohio.

33 miles, 20-in., proposed, Jefferson to Seneca, Ohio.

• **Oklahoma Natural Gas Co.**—50 miles, 18-in., planned, Sapulpa to Choteau, Okla. 7-53.

20 miles, 8¾-in., planned, Wewoka, Okla., south. 12-1-52.

• **Pacific Gas & Electric Co.**—50 miles, 12-16-20-in., planned, Fresno to Merced, Calif.

(Section 1) 16-in., Burrel to near Easton, Calif.

(Section 2) 20-in., Holm to Topock-Milpitas line.

(Section 3) 12-in., parallel existing Madera-Livingston line.

141 miles, 34-in., planned, parallel sections along Topock-Milpitas line.

Planned, Monterey to Fort Ord to Castroville; Napa Wye to Shellville; Cotati to Santa Rosa, Calif.

• **Pacific Northwest Pipeline Corp.**—1,384 miles, proposed, Ignacio, Colo., to Bellingham, Wash.

316 miles, proposed, laterals and spurs off main line to Pocatello, Idaho to Yakima, Wash.

Panhandle Eastern Pipe Line Co.—70 miles 24-26-in., under way, looping from Sneed, Tex., to Emporia, Kans.

174 miles, 30 and 26-in., contracted, Tuscola, Ill., eastward—looping present system; R. A. Conyes, contractor.

26-in., Edgerton, Mich., Anderson Brothers.

30-in., looping in Tuscola, Ill.

30-in., looping in Montezuma, Ind.

30-in., looping in Zionsville, Ind.

• **Panhandle Eastern Pipe Line Co.**—19 miles, planned, Peoria County, Illinois.

Pennsylvanian Gas Co.—52 miles, 12-in., between Warren and Erie, Pa. Section 1—27 miles, under way and contracted by Harford Brothers. Section 2—25 miles.

• **Peoples Natural Gas Co.**—25 miles, proposed, Cambria and Blair counties, Pennsylvania.

• **Permian Basin Pipeline Co. (Northern Natural).**—384 miles, 20-30-in., proposed,

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THE "American" LINE OF COLD PIPE, CONDUIT AND HEAVY WALL TUBE BENDERS HAND AND POWER

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bending cold pipe from ¼" to 6" I.P.S. inclusive

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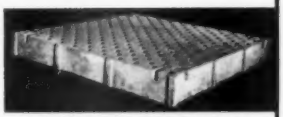

COMBINATION BENDING TABLES

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Roosevelt County, New Mexico, to Carson County, Texas.

• **Phillips Petroleum Co.**—125 miles, 2 to 24-in., planned, Midland, Upton, Glasscock, and Reagan counties, Texas. Completion date 3-53.

28 miles, 10-in., planned, Bayou Plant to Adams Terminal. Completion date 7-53.

Phillips Petroleum Co.—65 miles, 4 to 30-in., under way, Goldsmith field system, Texas. George Tucker, const. Completion date 1-53.

• **Public Service Co. of Colorado.**—95 miles, proposed, Douglas Creek and other gas fields to Grand Junction, Colo., area.

• **Public Service Co. of North Carolina.**—83 miles, 8-in., planned, Kings Mountain to Asheville, N. C. Completion date 3-1-53.

• **Rockland Light & Power Co.**—22 miles, 8-in., proposed, Orangetown to Tompkins, Cove, N. Y.

• **Shenandoah Gas Co.**—39 miles, 3-4-8-in., proposed, Middleton, Va., to Martinsburg, W. Va.

• **South Carolina Natural Gas Co.**—160 miles, 16-12-10-in., proposed, Aiken, S. C., to cities of Columbia, Summerville, and Charleston, S. C.

• **South Georgia Natural Gas Co.**—339 miles, 2-12-in., planned, Phoenix, Ala., to Tallahassee, Fla. (a) 12-in., Phoenix, Ala., to Albany, Ga. (b) 10-in., Albany, Ga., to Moultrie, Ga. (c) 8-in., Moultrie, Ga., to Tallahassee.

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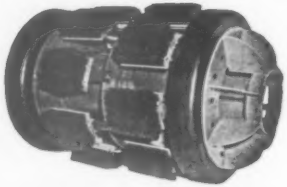

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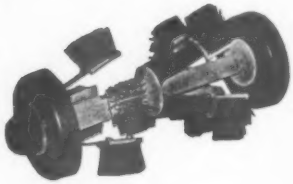

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WRITE FOR COMPLETE INFORMATION

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• **Southern California Gas Co.**—35 miles, planned, Antelope Valley, California.

• **Southern California Gas Co. and Southern Counties Gas Co. of California.**—45 miles, 30-in., proposed, looping on line from Arizona border to Los Angeles.

81 miles, 30-in., proposed, Whitewater to Desert Center, Calif.

Planned, looping between Blythe and Colorado River and on westward of Indio.

Southern Natural Gas Co.—1,235 miles, 24 to 4½-in., contracted, Louisiana, Mississippi, Alabama and Georgia, and South Carolina. Houston Contracting and H. C. Price.

88 miles, 24-in., Mississippi and Alabama. (2) Reform, Ala., to Warrior River. Houston Contracting. Completion date 12-1-52.

• **Southern Union Gas Co.**—21 miles, 20-in., planned, Albuquerque, N. M.

27 miles, 10-in., planned, Lea and Eddy counties, New Mexico.

Southern Union Gas Co.—30 miles, 12-20-in., contracted, San Juan County, New Mexico. R. H. Fulton & Co.

• **Southwest Gas Corp., Ltd.**—26 miles, proposed, from P.G.&E. line to Victorville, Calif.

• **Texas Eastern Transmission Corp.**—315 miles, 24-in., proposed, Provident City, Tex., to Castor, La.

• **Texas Gas Transmission Corp.**—408 miles, 26-in., under way, looping from Bastrop, La., to Jefferson Town Station near Louisville, Ky. Houston Contr. and H. C. Price Co.

• **Texas-Ohio Gas Co.**—1,435 miles, 30-in., proposed, Hidalgo County, Texas, through Arkansas, Mississippi, Tennessee, and Kentucky on to Spencer, W. Va. Completion date 6-30-53.

• **Union Oil Co. of California.**—40 miles, 8-10-in., planned, San Joaquin Valley and Los Angeles basin.

• **United Fuel Gas Co.**—50 miles, 20-24-in., proposed, Wood County to Lanham, W. Va.

• **United Gas Pipe Line Co.**—44 miles, 20-in., planned, Lirette field to Harvey, La.

Virginia Natural Gas Co.—153 miles Buckingham to Richmond and Portsmouth, Va.

Westcoast Transmission Co., Ltd.—(See foreign natural gas pipe lines).

Western Kentucky Gas Co.—2 to 4-in., under way, additions to present system; Modern Welding Co., Inc., contractor.

• **Western Pipe Lines.**—1,200 miles, 22-in., planned, southern Alberta to Duluth, Minn.

• **Wilcox Trend Pipe Line Co.** (Harry Bass Drlg. Co.)—150 miles, various up to 20-in., planned, gathering system for delivery to proposed Texas Eastern terminal at Provident City, Tex.

Foreign Crude-Oil Pipe Lines

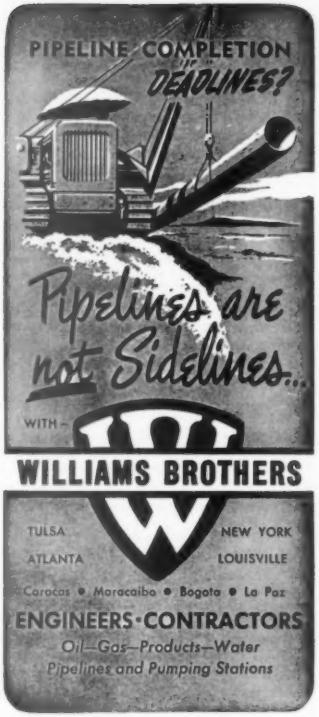
• **Basrah Petroleum Co.**—72 miles, 24-in., planned, Zubair to Fao. Begin May 1953.

Canadian Gulf Pipe Line Co.—115 miles, 4-6-12-in., under way, Big Valley and Fenn fields to Stettler field, Edmonton, Alta., Canada. Anderson International Contractors, Ltd.

• **Cia. de Petroleo Ganso Azul, Ltd.**—48 miles, 4-in., planned, Ganzo Azul field to Pucalpa on upper Ucayali River, Peru.

Creole Petroleum Corp.—143 miles, 26-in., under way, Ule (State of Zulia) to Amuay (State of Falcon). Williams Bros. de Venezuela, S. A., contractor of overland sections. general superintendent, Maracaibo. McWilliams, Gahagan, and Anderson Brothers, contractors of water crossings. Completion date March 1953.

• **Creole Petroleum Corp.**—25 miles, 34-in., planned, Lagunillas to La Salina (State



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of Zulia). Completion date April 1953.

Direccion General de Yacimientos Petroliferos Fiscales.—409 miles, under way, Plaza Huincul to Bahia Blanca, Argentina.

Interprovincial Pipe Line Co.—100 miles, 16-in., contracted, Regina, Sask., to Gretna, Man., Canada. Anderson International Contractors, Ltd.

Iraq Government.—135 miles, 12-in., from Iraq Petroleum Co. at Baija to Baghdad, Iraq. Construction 1952. M. W. Kellogg, contractor.

• **Mene Grande Oil Co.**—12 miles, 26-in., Anaco to Puerto La Cruz.

• **National Iranian Oil Co.**—38 miles, 12-in., planned, Lali to Masjid-i-Sulaiman.

27 miles, 12-in., planned, Kut-Abdullah to Zergan.

• **Petroleos Mexicanos.**—145 miles, 12-in., considered, 18 de Marzo field via Reynosa to Monterrey, Mexico.

100 miles, planned, Isthmus of Tehuantepec, Jose Colomo to El Plan field, Minatitlan.

• **Saskatoon Pipe Line, Ltd.**—56 miles, 6-in., planned, Milden to Saskatoon, Sask.

Texas Petroleum Co.—60 miles, 4-6-in., under way, Pta. Nino to La Dorada.

Trans Mountain Oil Pipeline Co.—711 miles, 24-in., under way, Edmonton, Alta., to Vancouver, B. C. Canadian Bechtel, Ltd. engineers. Completion date 8-53.

(Spread 1) Acheson to Lake Yellowhead. Comstock Midwestern.

(Spread 2) Lake Yellowhead to Blue River. Comstock Midwestern.

(Spread 3) Vicinity of Vavenby, Mannix, Ltd.

Foreign Products Pipe Lines

Columbia Ministry of Petroleum—100 miles, 8-in., contracted, Contemplara to Pto. Salgar, Williams Bros. Corp.

75 miles, 4-in., planned, Buena Ventura to Cali, Colombia.

113 miles, 6-in., contracted, Puerto Berrio to Acededo near Medellin, Colombia, Carolina Construction Co.

• **Empresa Nacional del Petroleo**—80 miles, 6⅝-in., planned, Concon to Santiago, Chile.

Empresa de Ferrocarriles Ecuatorianos.—56 miles, 6-in., contracted, Guayaquil to Palmira, Ecuador. J. A. Jones, contractor; C.R.C. Engineering Co., engineers.

• **Governments of Southern Rhodesia and Portuguese East Africa.**—200 miles, considered, Beria, Portuguese Mozambique to Umtali, Southern Rhodesia.

Societe des Petroles au Congo. (Sub Cie. Financiere Belge des Petroles, S.A.).—225 miles, 6-in., under way, Ango-Ango to Leopoldville, Belgian Congo. Completion date 2-53.

Imperial Oil, Ltd.—64 miles, 12-in., under way, Sarnia to London, Ontario. Comstock Midwestern, Ltd.

Societe des Transports Petroliers par Pipe Line.—160 miles, 10-in., under way, Le Havre to Paris, France. Entrepose, contractor. Completion date 1953.

Trans-Northern Pipe Line Co.—440 miles, under way, Hamilton, Ont., to Toronto, Ont., to Montreal, Que., Canada. Contracted by Mannix-Williams Bros. Ltd.

Under way, Kingston to Toronto. Sparling Davis.

Under way, Kingston to Montreal and branch line to Ottawa. Williams Bros.

Under way, Acheson to Edmonton. Canadian Pipe Line Const. Co.

Foreign Natural-Gas Pipe Lines

• **Azienda Generale Italiana Petroli.**—110 miles, 12-14-16-in. Start 11-52. Cortemaggiore to Genoa. Completion date 11-53.

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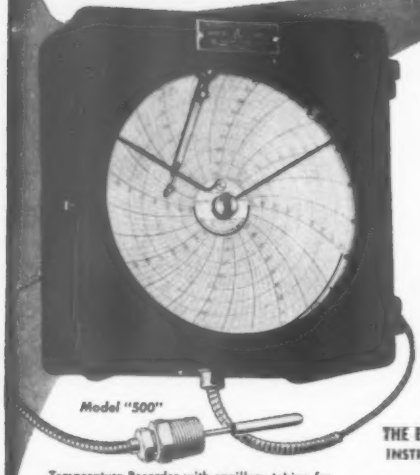

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Azienda Generale Italiana Petroli — 90 miles, 12-in., under way, Cortemaggiore to Bologna, Italy, SNAM crews.

120 miles, 16-in., under way, Cremona Porto Mar to Ghera, Italy, Montubi, contractor.

40 miles, 12-in., under way, Ripalta-Bergamo, Italy.

Direccion General del Gas del Estado.— 310 miles, 8-in., under way, Plaza Huincul to Neuquen, Argentina, to the vicinity of General Conesa, Argentina.

• **Empresa Nacional del Petroleo**—80 miles, 10¾-in., planned, Concon to Santiago, Chile.

• **Northwest Natural Gas Co.**—950 miles, 24-in., planned, Alberta fields to Vancouver, B. C., Seattle, Wash., and Portland, Ore.

• **Petroleos Mexicanos.**—205 miles, 16-in., under way, Monterrey to Torreon, Mexico.

Petroleos Mexicanos. — 260 miles, 20-in., considered, Monterrey to Tampico and Poza Rica, Mexico.

Under way, Salamanca to Guadalajara, Mexico.

• **Petroleos Mexicanos, Mexican Gas Co., and Industrial Gas Co.**—600 miles, planned, Reynosa, Tamaulipas, to Tampico-Poza Rica, Mexico.

• **Trans-Canada Pipe Lines, Ltd.** (Canadian Delhi Oil Co.)—2,247 miles, 14 to 30-in., proposed, Alberta to Toronto to Montreal.

747 miles, 8 to 24-in. gathering system in Alberta.

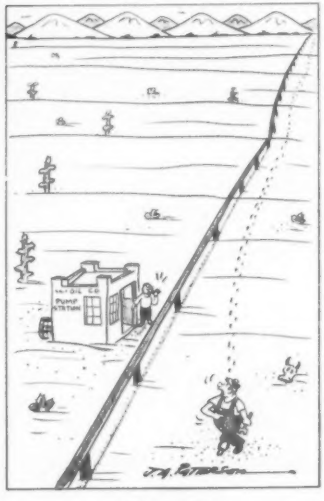
• **Westcoast Transmission Co., Ltd.**—1,110 miles, 24-in., planned, Dawson Creek, B. C. through Pine Pass and Fraser River Valley to Kamloops, Princeton, and Vancouver to Portland. Ford, Bacon & Davis, engineers.

280 miles, 20-in., planned, Pincher Creek to Montana on to Spokane, Wash. Ford, Bacon & Davis, engineers.

138 miles, 20-in., planned, Sumas to Tacoma, Wash.

139 miles, 18-in., planned, Tacoma, Wash. to Portland, Ore.

• **Western Pipe Lines.**—833 miles, 24-in., proposed, from southern Alberta, eastward across the Canadian prairies, serving principal towns and cities along the route to a point near the International boundary.



"Who—me?"

PIPE LINES

New Gas Supply

FPC approves $32,518,500 Southern Natural project

WASHINGTON.—Southern Natural Gas Co. has received the green light from the Federal Power Commission to launch its $32,518,500 construction program to take gas from 12 fields in southern Louisiana and southern Mississippi.

The new supply system is a part of one phase of a planned five-pronged, $76,365,200 expansion along Southern Natural's entire system in the South *(The Oil and Gas Journal, July 21, page 44)*.

The entire project calls for construction of more than 1,235 miles of lines and installation of 24,250 hp. in compressor units at new and existing stations. It would increase Southern Natural's daily delivery capacity from the present 670,000,000 cu. ft. to more than 1,020,000,000 cu. ft. The remainder of the construction is still pending FPC authorization.

The expansion just approved by FPC involves construction of more than 326 miles of lines and about 8,700 hp. in new compressor capacity. The facilities include:

... A 68-mile, 24-in. line running south from the company's Gwinville, Miss., compressor station to Franklinton Junction, La., and a 19-mile, 8-in. lateral running east to Sandy Hook field in Mississippi.

... A 110-mile, 20-in. line extending southwest from Franklinton Junction to Duck Lake field, Louisiana, and a 13-mile, 10-in. line from Duck Lake to Lake Sand field.

... A 118-mile, 20-in. line from Franklinton Junction to a point in Plaquemines Parish, Louisiana, together with lateral lines to various fields in the area.

... A new 3,300-hp. compressor station on the latter line at Estopinal, La.

... A 5,400-hp. addition to the company's compressor station at Gwinville.

Delivery capacity of the system from Franklinton to Gwinville will be almost 300,000,000 cu. ft. of gas daily.

The commission conditioned the authorization to require that construction be completed and the system in operation by January 1, 1954. The facilities are not to be used to serve any of the new markets proposed by the company in its application for the entire project unless they are further authorized by the commission.

Intermediate-decision procedure was omitted by FPC in the hearing on the supply system, since contracts negotiated by Southern Natural for gas in the Mississippi and Louisiana fields called for the company to obtain FPC permission to construct the facilities by dates ranging from November 3 to February 1.

Big Line Rejected

Texas-Ohio evidence not sufficient, FPC declares

WASHINGTON.—Texas - Ohio Gas Co.'s application to build a $185,000,000 natural gas line from the Mexican border in Hidalgo County, Texas, to near Lancaster, Ohio, has been turned down by the Federal Power Commission.

FPC said the company failed to show that the operation of the proposed 1,406-mile line is required by "present or future public convenience and necessity."

Texas-Ohio planned to sell all of its gas to Reserve Natural Gas Co., a newly formed corporation at the Ohio terminus of the big trunk line.

FPC said that on a 95 per cent load-factor basis, Texas-Ohio would require 480,000,000 cu. ft. of gas per average delivery day, plus 32,000,000 cu. ft. for fuel and line loss. The company proposed to secure about 232,000,000 cu. ft. of the needed gas from Mexico, about 173,000,000 from natural-gasoline plants, and 107,000,000 cu. ft. more from gas fields in Texas.

The commission said the company submitted a proposed contract with the Mexican oil agency, Petroleos Mexicanos, which it said was never executed.

The document contained a provision that Texas-Ohio must secure an FPC certificate by July 31, 1952, and begin construction by September 15, 1952, the commission said.

FPC said the company submitted no gas-reserve or deliverability estimates in support of its gasoline-plant gas commitment, and only 18,200,000 cu. ft. of the proposed field gas purchases were covered by purchase contracts.

Texas-Ohio testimony, the commission said, also was nebulous as to whom and in what volumes Reserve Natural intends to sell the gas, as to Reserve Natural's ability to absorb and pay for the 480,000,000 cu. ft. of gas per day,

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and as to the economic feasibility of the project.

Rule protested . . . Frank Champion, president of Texas-Ohio, said the commission's ruling does not reflect the facts.

Champion said the company intends to carry the case further.

"We feel that the manner in which the Texas-Ohio case was handled by the Federal Power Commission deprived the applicant, from the inception of the case, of due process and violated the requirements of the Administrative Procedure Act," Champion said.

He added that "so long as the Federal Power Commission interprets the Natural Gas Act as it has in this case, no independent can hope to get a permit to transmit gas.

Texas Gas Looping Project About 50 Per Cent Completed

OWENSBORO, Ky.—Construction of 408 miles of 26-in. loops along Texas Gas Transmission Corp.'s main line now is more than 50 per cent completed, the company said last week.

More than 225 miles of line had been laid by the end of October—82 miles of the total laid during that month.

Five spreads have been working on the project. The 46-mile section between Bastrop, La., and the Mississippi River was completed about the middle of October. The 125-mile spread from the Mississippi to a point near the Mississippi-Tennessee line was completed early this month.

Work is still going ahead on the remaining three sections. At the end of October, about 12 miles of the 69-mile Tennessee section had been laid; about 42 miles of the 87-mile Kentucky spread was in the ground; and about 3 miles of the 80-mile Owensboro spread was completed.

Machine Developed to Make Smooth Bends in Big Pipe

HOUSTON.—A new piece of pipeline equipment claimed to be the first machine capable of making smooth bends in pipe as large as 36 in. in diameter has been announced by Crutcher-Rolfs-Cummings, Inc.

C-R-C developed the machine in cooperation with Transcontinental Gas Pipe Line Corp.

The device is track-mounted, weighs 33,000 lb., and measures 7⅔ by 24½ ft. C-R-C said the machine in recent tests smooth-bent cold pipe with a wall thickness of .395 and a nominal yield strength of 52,000 lb. by ½° per foot.

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NATURAL GAS

Boston Consolidated Appeals FPC Rule Against Algonquin

BOSTON. — Boston Consolidated Gas Co., Algonquin Gas Transmission Co.'s biggest prospective customer, appealed to the Federal Power Commission last week to reconsider its refusal to let Algonquin place its big New England gas line in operation pending further hearings on division of market areas in that region.

Algonquin's $50,000,000 main line is ready to serve such cities as Boston, Hartford, and New Haven.

A Boston Consolidated official said it seems unbelievable that a pipe line almost ready to deliver natural gas to protect the welfare of southern New England should have to lie idle "when putting the line in operation pending final disposition of the case could do no harm."

The hearings beginning November 24 will reopen the question of whether Algonquin or Northeastern Gas Transmission Co. should serve the New England market originally set aside for Algonquin *(The Oil and Gas Journal, November 10, page 193).*

OPS Issues Order Limiting Escalation of Gas Prices

WASHINGTON. — The long-awaited Office of Price Stabilization "escalation" order has been signed by Tighe Woods, price stabilizer.

The order, Amendment 8 to Ceiling Price Regulation 17, becomes effective November 17.

It authorizes escalation clauses in natural-gas contracts to be carried out if the contracts were in force before January 25, 1951. However, it sets out that other sellers in the same field may not use the escalated price as a basis for an "in-lining" action if this action would puncture the current ceiling field prices in the area.

Regeneration Gas Streams Offer New Source of Revenue

TYLER, Tex.—Recovery of hydrocarbons from cooled regeneration gas streams offers a new source of revenue in units employing solid-desiccant dehydration units, E. Paul Wilkinson, Magnolia Petroleum Co., Dallas, Tex. said here recently at the southern regional meeting of the Natural Gasoline Association of America.

Wilkinson said that many new installations now provide an accumulator tank that will permit the recovery of distillate and/or absorption oil after towers have been regenerated. A recovered barrel of these products is worth about $2.65. Payout period for recovery of the desiccant cost has been as short as 90 days in some cases.

Wilkinson said that some natural-gas-transmission companies have lowered their dew-point requirements specifying that acceptable residue gas must have a dew-point not to exceed —100° F.

This can be attained if these operating conditions are set up: (1) proper contact time, e.g. 30 to 50 seconds, (2) velocities not to exceed 25 ft. per minute, and (3) careful control of piping and valve arrangements.

Every precaution should be taken to insure against leaking valves on regeneration piping. Dew points of —150° F. have been reached using S/V Sovabead, desiccant.

September Sales Up 11.5 Per Cent Over Last Year's

NEW YORK.—Sales of natural gas during September this year climbed to 3,283 million therms—a gain of 11.5 per cent over the 2,946 million therms sold during September 1951, the American Gas Association reports.

A.G.A.'s monthly report shows that sales of natural gas totaled 47,083 million therms for the 12 months ended September 30. This is an increase of 8.7 per cent over the same period a year earlier.

Natural Gasoline

Panoma Increases Output of Carson County, Texas Plant

AMARILLO, Tex.—Panoma Corp. recently completed installation of new equipment at its Carson County, Texas, natural-gasoline plant, boosting its output of products from 85,000 gal. to 125,000 gal. per day.

New equipment included a rich-oil demethanizer, a heat exchanger, and larger oil-circulation pumps. Expansion of the volume of products was accomplished without increasing the plant's input rating of 100,000,000 cu. ft. of natural gas daily.

Production at the plant currently is 16,500 gal. of motor fuels, 89,500 gal. of L.P.G., and 19,000 gal. of isomers. The totals before the expansion were 14,500 gal. of motor fuels, 55,500 gal. of L.P.G., and 15,000 gal of isomers.

The plant gets its supply of natural gas from fields in Carson and Gray counties in the Texas Panhandle. All of the residue gas is sold.

Pure Hikes Production at Dollarhide Field Plant

MIDLAND, Tex.—Pure Oil Co. has completed installation of three 1,350-hp. compressor units at its Dollarhide field natural-gasoline plant in Andrews County, West Texas, raising gross gas-processing capacity roughly 14,000,000 cu. ft. daily.

Products output has been increased from the former 72,000 gal. of natural gasoline and 119,000 gal. of L.P.G. to a new total of 84,000 gal. of gasoline and 136,000 gal. of L.P.G.

Sid Richardson Completes Expansion of Keystone Plant

KERMIT, Tex. — Sid Richardson Natural Gasoline Co. recently completed an expansion of its natural-gasoline plant in Keystone field, Winkler County, to produce about 15,000 gal. more products daily.

New output is 45,000 gal. of natural gasoline and 90,000 gal. of L.P.G. per day. Production prior to the expansion was 40,000 gal. of natural gasoline and 80,000 gal. of L.P.G. daily.

To provide the increased production, the company added one 2,200-hp. and one 1,320-hp. compressor. About 600 hp. of the first unit was added to the existing 600 hp. employed in the propane-refrigeration system.

Input rating of the plant was increased from the old 75,000,000 cu. ft. daily to 84,000,000 cu. ft. daily.

Texas Standard Installs Facilities at Snyder Plant

SNYDER, Tex.—Standard Oil Co. of Texas has completed installation of new isobutane facilities at its natural-gasoline plant here.

The new equipment, which included a depropanizer and butanes splitter, is enabling the company to produce about 8,000 gal. daily of isobutane. The plant also is manufacturing 61,000 gal. of natural gasoline and 54,000 gal. of other L.P.G. products.

Before the new facilities were installed, plant output was 61,000 gal. of natural gasoline and 62,000 gal. of L.P.G.

The company's Snyder plant handles about 22,000,000 cu. ft. of natural gas daily from Kelly-Snyder field.

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PROBLEM—In every industry, designers and production engineers are constantly confronted with the problem of combating friction. Every turning part of machinery presents problems of speeds and loads—sometimes radial, sometimes thrust loads—usually both.

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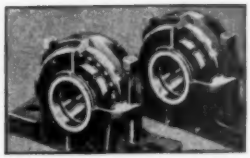
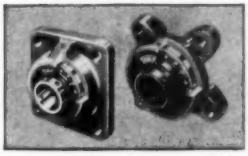


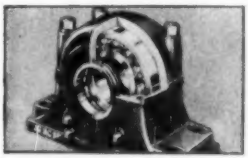
SERIES SAF—Ball or roller bearing pillow blocks, with Triple-Seal rings which keep dirt out, lubricant in. Wide range of load-carrying capacities.

SERIES SES and SY—Unit ball bearing pillow blocks. The SES is mounted in rubber, prevents transmission of noise. The SY permits liberal misalignment—is effectively sealed by famous SKF Red Seal.

SERIES SUS and SUA—Unit ball bearing pillow blocks (SUAR equipped with spherical roller bearings). Ring seals exclude dirt. The SUA is an adapter-type mounting.



SERIES FUS and FUA—Ball bearing flanged unit having same features as SUS and SUA pillow blocks. (FUAR equipped with spherical roller bearings).



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CYCLOVERSION* AT MEXICO CITY, MEXICO

PEMEX started up this Cycloversion Unit on July 1, 1952. It has a capacity of 12,000 barrels a day. Plans are now under way to increase the capacity to 20,000 barrels a day.

At present, the unit is being used for catalytic desulfurization of straight-run and thermal cracked gasolines. As a result, PEMEX has been able to improve the quality of their regular grade gasoline and increase the quantity of the premium grade. In addition, during the first month of Cycloversion operation, the TEL requirements for this refinery's gasoline production were 74,000 pounds less than for the preceding month.

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REFINING

Construction to Begin on New Petrochemical Plant

ORANGE, Tex.—The Nitrogen Division of Allied Chemical & Dye Corp. will shortly begin construction of a $5,000,000 plant near here to manufacture ethylene oxide, ethylene glycol, diethylene glycol, and triethylene glycol.

The unit is scheduled for completion in the spring of 1954. It will represent Allied's first entry into the synthesis of these products.

Petroleum ethylene will be supplied from nearby Port Arthur by pipe line.

Phillips Completes Plant Expansion at Woods Cross

WOODS CROSS, Utah. — Phillips Petroleum Co. has completed a modernization and expansion program at its Woods Cross, Utah, refinery located north of Salt Lake City.

The project included expansion of crude-charge capacity from 4,200 to 10,000 bbl. per day and the addition of an 8,000-bbl. Thermofor catalytic cracking unit, built by Flour Corp., Ltd.

The new facilities at Woods Cross will permit Phillips to meet market demands normally supplied by the company's Pocatello, Idaho, refinery.

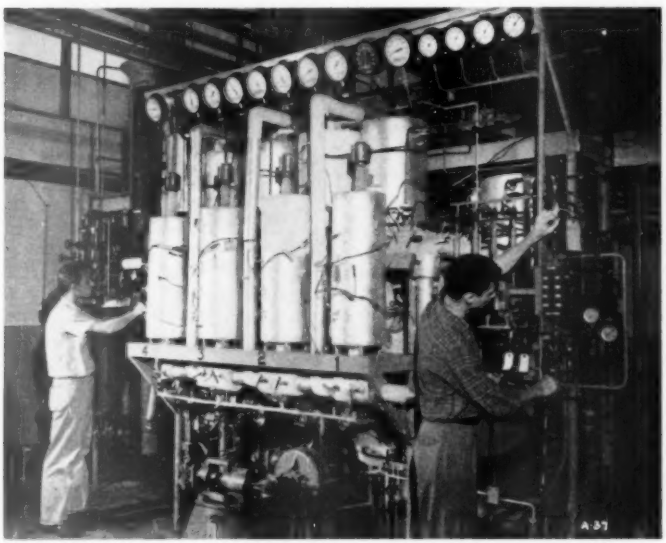
Products from Woods Cross will be moved northward through the Intermountain region through Salt Lake Pipe Line Co.'s line from Salt Lake City to Pasco, Wash.

Late this year, the 3,500-bbl. per day skimming and cracking plant at Pocatello will be shut down.

Phillips acquired both plants since the war. The Woods Cross refinery was purchased from Wasatch Oil Refining Co., and the Pocatello plant from Idaho Refining Co.

Booklet on New Motor-Oil Designation Now Available

WASHINGTON.—The Division of Marketing of the American Petroleum Institute has revealed that a booklet explaining the new A.P.I. service classifications and designations for motor oils now is being made available to the oil and automotive industries.



Idea Factory

In this Marcus Hook, Pa., research and development laboratory, Houdry Process Corp. operates 15 to 20 pilot plants trying out new processing ideas and investigating sources of trouble in operating commercial units. Pictured here is one of the Houdriforming pilot units for upgrading naphthas and producing aromatics. The pilots continue to function after a process has been developed commercially. Such studies constitute the basis for improvements in design and operation.

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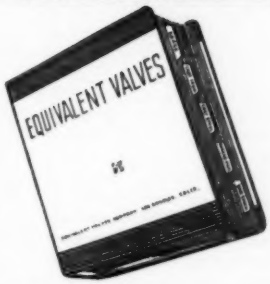

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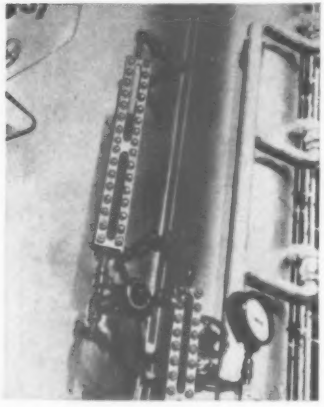

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The new system of classifications, the booklet points out, will be of direct benefit to the public because it "provides a more logical basis for selecting the right oil for any engine under any service condition and affords greater opportunity for the development of better oils to meet specific service conditions without regard to other requirements.

Refinery Cash-Dividend Payments Still Climbing

WASHINGTON.—Publicly reported cash-dividend payments by refining corporations during the first 9 months of 1952 were $97,000,000 above those of the corresponding period last year.

Commerce Department statistics show that this increase, 16 per cent, was the largest reported by any major industry and that oil refining so far this year tops even finance in dollar distribution.

Atlantic Introduces New Nonsoluble Cutting Oils

PHILADELPHIA. — New additions and improvements to its line of nonsoluble cutting oils have been made by Atlantic Refining Co.

A feature of the new oils is their transparency, from light to heavy grades, which results from the use of a new additive.

According to Atlantic, the new line of oils will provide reduced friction, superior cooling, anti-weld and metal-wetting characteristics.

Refining Briefs

Vickers Petroleum Co. has revealed it will undertake a major expansion program, which includes the installation of a $3,500,000 catalytic cracking unit at its Potwin, Kans., refinery next year.

Lion Oil Co. said last week that construction of its two major projects was not delayed as much as anticipated by the steel strike earlier this year and currently is about on schedule. T. H. Barton, chairman of the board, and T. M. Martin, president, said the $5,000,000 expansion of the El Dorado, Ark., refinery is expected to be completed during the third quarter next year; while Lion's new Barton petrochemical plant near New Orleans will be ready for operation about the middle of 1954. The latter plant will cost an estimated $31,000,000.

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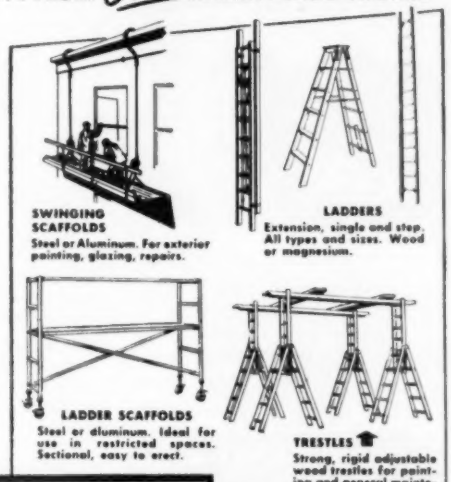

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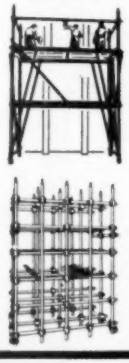

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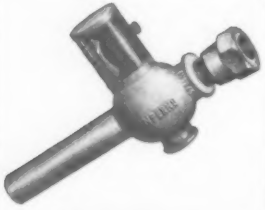

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Among the Drilling Contractors

New Company Acquires Royalite Drilling Rigs

All drilling equipment formerly owned and operated by Royalite Oil Co., Ltd., one of western Canada's most active independent producing and operating companies with headquarters at Calgary, has been acquired by Petrolia Drilling Co., Ltd., a newly organized drilling contracting company, also headquartering at Calgary.

Organizers of the new contracting company are K. H. Houston, formerly vice president and operations manager of Royalite, and F. J. Cameron, formerly manager of the same company's industrial relations department.

Milton Crow, Inc., Shreveport, is handling the contract for R. A. Stacey's 6,000-ft. Pettit lime test, 1 Hines, C NE NE 36-19s-21w, in southern Columbia County, southern Arkansas. Location is slightly more than 2 miles southeast of the new Horsehead field, and 2¼ miles northwest of the Haynesville field, both of which produce from the Pettit.

Nebraska Drillers, Inc., Denver, is drilling for Anderson-Prichard Oil Corp. of Oklahoma City at a wildcat test, 1 Wilkinson, being started in the Pine Bluffs area, 36 miles east of Cheyenne, in Laramie County, Wyoming. Operators plan to carry the hole to 7,800 ft., which should provide a look at the Cloverly series.

West Texas Firm Moves

Aldridge & Stroud, Inc., West Texas-New Mexico drilling contracting firm, has moved its main offices from Odessa to McCamey, but will maintain a branch office at the former place. The company operates eight cable-tool rigs.

Coffield & Guthrie are contractors on a wildcat test which T. J. Johnson is undertaking at 1 Ida Jackson heirs, 3½ miles northwest of Coolidge in the W. P. Baxter Survey, Limestone County, eastern Texas.

Dyer Drilling Co., Denver, has a contract for a 5,000-ft. Tensleep test to be drilled for Kirby Petroleum Co. at West Douglas, 8 miles west of Douglas, in Converse County, Wyoming. Location is for 1 Jenkins, in Lot 2, 13-32n-72½w.

Delta Drilling Co., Tyler, Tex., has a new contract operation under way for K. & H. Operating Co. of Houston in the Opelika field, 4½ miles northeast of Murchison, Henderson County.

Day-tour crew on a rotary rig LaGloria Corp. of Corpus Christi is operating in the Waskom field, Harrison County, eastern Texas. Top, left to right: E. L. Goley, L. B. O'Keefe, and C. F. Oates (driller). Kneeling, left to right: J. F. Diess and S. E. Barvin. (Picture by courtesy of Mission Manufacturing Co., Houston).

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East Texas. Location is for 1 Rowan in the J. S. Reed Survey. Contract is for 10,000 ft.

Balderson Drilling Co., Denver, is contractor for Fred Manning, Jr., at 1 State, a wildcat test in the SW NW NE 26-8n-54w, 4 miles southwest of Springdale, Logan County, Colorado.

Hobart - Cockburn tools are being used on a Tensleep wildcat test which Fremont Petroleum Co. has under way at Horse Center, 6 miles east of Cody, in Park County, northwestern Wyoming. The test, 1 Moyer, is in the SW NE NW 31-52n-101w.

Northern Drilling Co., Kevin, Mont., has a rig working under contract for Denton and associates at a wildcat test, 1 Hansen, in the NW NW NW 36-15n-31w, northwest of North Platte, Lincoln County, Nebraska.

Survey Drilling Co., Dallas, has contracted with Amerada Petroleum Corp. for a stratigraphic test at 1 Seedorf, in the SW SW NE 6-2s-48w, in Yuma County, Colorado. Hole will be carried to the Mississippian.

Ray Holbert Drilling Co. has a rig running for S. J. Felsenthal of Longview in the Willow Springs field, 4 miles northwest of Longview, Gregg County, East Texas. Current operation is at 1 Castleberry, in the William Robinson Survey. Hole is projected to 7,500 ft.

Moore Drilling Co., Billings, Mont., has a 2,500-ft. Weber sand test under way at Split Mountain, 6 miles southeast of Ashley Creek, in Uintah County, Utah. It is drilling for Signal-Uinta Oil Co. The test, 1 Government, is located in the NE NE NW 1-6s-23e.

ACTIVE ROTARY RIGS*

(United States and Western Canada)

Area—	Week ended 11-10-52	Change week ended 11-3-52	Change week ended 11-12-51
Gulf Coast	598	+ 8	— 60
N. & W. Tex.-N. M.	841	+47	—198
Ark.-N. La.-E. Tex.	143	—10	— 41
Oklahoma	319	—11	+ 28
Kansas-S. Nebraska	175	+16	— 18
Illinois-Eastern	146	0	+ 2
Rocky Mountains	236	—14	+ 45
Pacific Coast	169	— 1	— 7
Total U. S.	2,627	+35	—249
Western Canada	179	+ 3	+ 25
Total	2,806	+38	—224

*Courtesy Hughes Tool Co. Trends in drilling activity in the United States and the North and West Texas-New Mexico and Oklahoma-Kansas areas are shown on pages 474 and 475.

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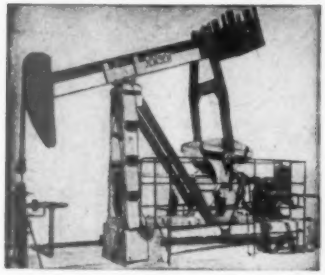

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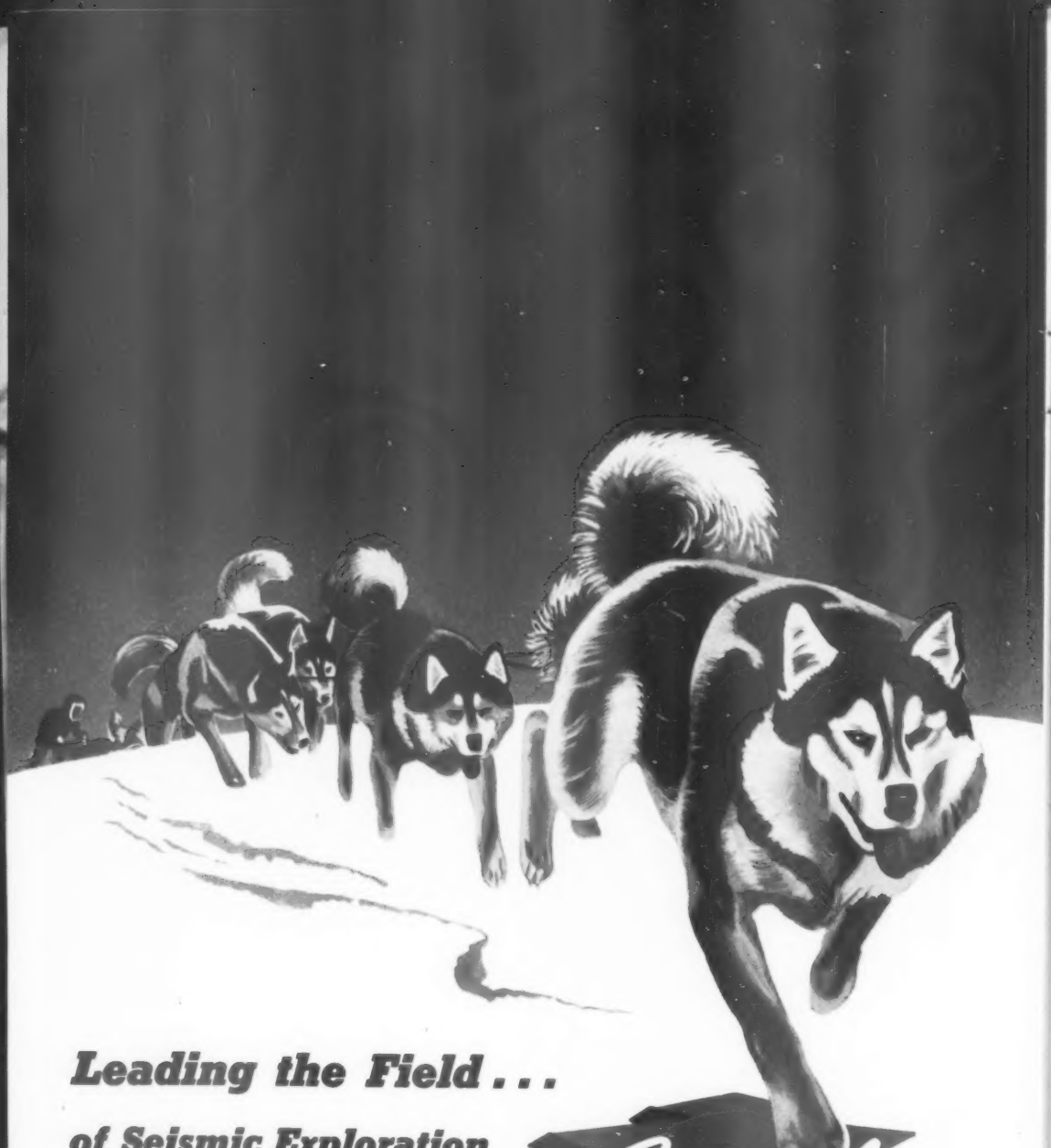

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Sand Studies Keep Texas Area Active

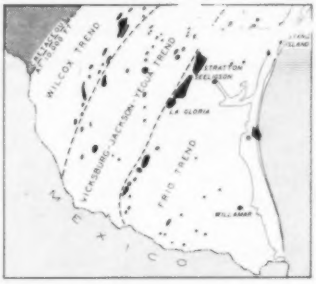
GEOLOGISTS of Texas' lower Gulf Coast foresee many more years of profitable oil hunting in and around the prolific producing areas of the Frio, Vicksburg - Jackson - Yegua, and downdip Wilcox trends.

Their optimism prevails despite a high density of drilling; in fact, it is the great number of electrical logs available that account for much of their optimistic outlook. This is because their search, except for the sparsely tested portions of big ranches and the southeastern counties of the province, is based almost exclusively on subsurface studies. The 25,000 or so bore holes in the area offer a wealth of subsurface control from which detailed correlations and intricate sand maps are being worked out to point the way to the hard-to-find but obviously numerous future fields.

The Tertiary sands of this province are believed to follow a similar pattern in each of the three producing trends shown on sketch map in a generalized way and in the potential Miocene trend downdip (gulfward) from the Frio trend. In cross-section this pattern shows a zone of maximum sand development (a massive sand body 0 to 40? miles east-west in the case of the Frio) which pinches out both updip and downdip by breaking into numerous sand tongues. Though these tongues are erratic in their areal extent, in general the lower sand tongues extend the farthest westward in the updip pinchout and the middle sand tongues extend the farthest eastward in the downdip pinchouts.

It is obvious that the updip pinchouts offer ideal stratigraphic traps for oil accumulation, with or without structural help. It has been these traps that have yielded many of the reservoirs producing in the three trends and it is the search for updip pinchouts of the numerous tongues, particularly where they occur on the gulfward flank of known structures, that dominates activity in the area today.

However, comparatively recent developments have indicated that downdip porosity and permeability wedges may play a competitive role in future studies. It has been found that oil and gas-bearing traps are formed in downdip pinchouts when the regional dip of the sands involved is interrupted by doming and fault blocks resulting, perhaps, from deep-seated salt domes. Fields of the Mustang Island area have indicated the existence of oil and gas traps in some of the Frio sands formed by downdip pinchouts on the western flank of producing structures.



An indicated discovery of special interest because of its location in what has been considered the normally dry massive portion of the Frio sand is arrowed on sketch. This well flowed 38°-gravity oil on a drill-stem test of a shallow (for the area) Frio sand. Only small gas wells have been found for at least 30 miles in any direction. This indicated discovery and Willamar field to the south suggest the possibility that additional sand bodies may exist downdip—sand bodies which repeat the pattern recognized to the west but in a younger and offlapping development.

Most of the essentially productionless area fanning out to the west from the arrowed well is the King Ranch where Humble Oil & Refining Co. has a blanket lease. Except for competitive drilling in the ranch portions of Seeligson (Borregas) and Stratton-Agua Dulce, development of this million-acre area will be leisurely. A number of untested structures have been mapped on this big ranch.

The search for liquid hydrocarbons continues at a high, increasingly competitive rate throughout most of this important producing area. Perhaps no more giant fields will be found in Texas' lower Gulf Coast, but 50 or more 1 to 5-million-barrel pools can be expected year after year for many more years.

Philip C. Ingalls.

HIGHLIGHTS OF WEEK'S DEVELOPMENTS

NORTH DAKOTA . . . Amerada Petroleum Corp. has opened a new field 6 miles south of production at Beaver Lodge with the completion of 1 North Dakota "E," C NW NW 16-154n-95w. The well was finaled for a gage of 50 bbl. of oil and 33 bbl. water daily from the Madison.

WYOMING . . . Stanolind Oil & Gas Co. has reported a flow of 39 bbl. of fluid in 6 hours at their Middle Mountain wildcat in Sweetwater County. The flow was approximately 4 per cent water cut, and gas at the rate of 2,280 M.c.f. per day accompanied the oil flow from the Mesaverde sand.

WEST TEXAS . . . Amerada Petroleum Corp. 1 Weems, northwest Yoakum County discovery, has been completed for a daily potential of 1,934 bbl. of oil. Potential was based on an actual flow of 967 bbl. in 12 hours through ¾-in. choke from perforations in the Devonian at 11,773-11,860 ft.

MISSISSIPPI . . . The most encouraging development in the Paleozoic area since the Muldon field discovery well was completed was announced at Shell Oil Co.'s 1 Mrs. Lee Harrington, 25-14s-6e, Monroe County. On a 28-minute drill-stem test of the Hartselle at 3,514-51 ft. the well flowed an unestimated amount of dry gas.

North-Central Texas

New Conglomerate Producer Evident Near Nocona

WICHITA FALLS.—A new conglomerate producer south of Nocona was in prospect on the basis of drill-stem tests. First test at J. B. Revier 1 J. D. Gray from 5,684-5,692 ft. returned 4,580 ft. of clean oil and 20 ft. of oil-cut mud in 1 hour. Second test, open 1 hour and 45 minutes, from 5,854-67 ft. developed 80 ft. of salty oil-cut mud. Location is in Block 108, A. B. Buffington Survey.

Montague County gained a 7,100-ft. wildcat 4 miles south of Bowie as Bay Petroleum Co. 1 A. B. Ford, located in the I. Garner Survey, A-287, 2 miles southeast of production.

In Jack County, new Bend conglomerate production was in prospect at Charlie Grace Production Co. 1 Johnson, 3½ miles west of Jacksboro. A 6½-hour production test gaged 166 bbl. of oil through 24/64-in. choke. Total depth was 5,051 ft.

The same operator has made location for a 5,300-ft. wildcat 3 miles northwest of Jacksboro, which will be the 1 Bessie Mae Thompson. Location is in the C. Vandever Survey, A-868.

Russell Maguire will drill 1-F Cherryhomes as a 5,400-ft. wildcat 4 miles northwest of Joplin. Location is in the Wampler Survey, A-2,180.

NORTH CENTRAL TEXAS (DISTRICTS 7-B AND 9) SUCCESSFUL WILDCATS

Archer County: W. C. Wainwright 2 O. Calvin, Sulphur FK Iron Sur., 5 miles NE Olney, TD 1,097 ft., pay 1,094 ft., IP pumped 125 bbl. oil.

Lewis W. Welch 1 C. L. Abercrombie, Harris Subd., 3½ miles W Archer City, TD 5,466 ft., elev. 1,022 ft., Ellenburger pay 5,434 ft., IP 221 bbl. 42°-gravity oil, 13/64-in. choke, TP 100 psi., GOR 305 cu. ft.

Brown County: W. T. Pulliam 1 H. L. Alcorn, Sec. 32, A. D. Neil Sur. 41, 5 miles NW Brooksmith, TD 1,142 ft., elev. 1,512 ft., pay 1,128 ft., IP pumped 21.8 bbl. 40°-gravity oil.

Callahan County: Cities Service Oil Co. 1 Johnson, Sec. 278, A. J. Bear Sur., 1½ miles SE Oplin, TD 4,513 ft., elev. 1,959 ft., pay 3,663 ft., IP 211 bbl. 37°-gravity oil, 18/64-in. choke, TP 725 psi., GOR 3,061 cu. ft.

Clay County: L. T. Burns 1 J. M. Staats, Blk. 65, J. H. Belcher Subd., 1 mile Deer Creek field, TD 4,629 ft., pay 4,616 ft., IP pumped 51 bbl. 42°-gravity oil.

Jones County: Lester & Duffield 1 Walter S. Pope, Sec. 4, J. S. Hail Sur., 15 miles SW Albany, TD 3,368 ft., elev. 1,848 ft., pay 2,665 ft., IP pumped 108 bbl. 40°-gravity oil.

Montague County: Jack Grace Production Co. 1 H. J. Ray, Sec. 27, Jack CSL, 3 miles SW Stoneburg, TD 6,181 ft., pay 6,023 ft., IP 294 bbl. 42°-gravity oil in 10 hours, 24/64-in. choke, TP 750 psi., GOR 400 cu. ft.

Nolan County: Payne Johnson 1 Jessie Little, 25-20-T&P, 4 miles W Trent, TD 5,414 ft., elev. 1,988 ft., pay 5,365 ft., IP 152 bbl. 48°-gravity oil in 5 hours, ¼-in. choke, TP 900 psi., GOR 1,108 cu. ft.

Stephens County: Connally-Jackson 1 Plumb heirs, 16-7-T&P, TD 4,141 ft., elev. 1,496 ft., Marble Falls pay 3,825 ft., IP 167 bbl. 42°-gravity oil, 16/64-in. choke, TP 235 psi., GOR 857 cu. ft.

Taylor County: Geochemical Surveys 1 John Shannon, 26-148-GCS, ¼ mile NE Merkel, TD 2,632 ft., elev. 1,868 ft., pay 2,264 ft., IP pumped 85.5 bbl. 41°-gravity oil.

Young County: C. B. Christie 1 G. B. Hamilton, Blk. 1,809 and 1,810, TE&L Sur., 4 miles NE Olney, TD 5,150 ft., Caddo pay 4,966 ft., IP pumped 36 bbl. 41°-gravity oil.

NORTH CENTRRAL TEXAS (DISTRICTS 7-B AND 9) WILDCAT FAILURES

Archer County: Archer Drilling & Producing Co. 2 A. L. Harris, Blk. 59, John Harris Sur., dry, TD 1,384 ft.

Archer Drilling 1 Slaughter, Blk. 15, M & M Pasture Subd., dry, TD 1,472 ft.

Luke Grace Drilling Co. 1 Schrieber, 43-4-Clark & Plumb, dry, TD 4,507 ft.

Miami Operating Co. 2 F. J. Schroeder, 27-4-Clyark & Plumb, dry, TD 1,146 ft.

Young & Shappell 1 Walsh, Blk. 2,416, TE&L Sur., dry, TD 1,425 ft.

Brown County: Anderson Production Co. 1 Newman & Pickle, C. B. Jennings Sur. 353, dry, TD 1,562 ft.

Wilcox Investment Co. 1 L. V. Eddington, R. G. Milliken Sur. 142, dry, TD 1,301 ft.

Coleman County: Don L. Choate 3-25 Ballard, Sec. 25, GH&H Sur., dry, TD 2,526 ft.

J. W. Quinn Jr. 1-A Allen, Ses. 44, M. Cheaves Sur., dry, TD 1,978 ft.

Gary Wright 1 J. T. Blair, Sec. 20, GH&H Sur., dry, TD 3,102 ft., elev. 1,856 ft., Gardner 2,852-35 ft., Caddo 3,050-3,102 ft.

Eastland County: F. Kirk Johnson 1 A. J. Pippen, Sec. 3,182, TE&L Sur., dry,

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Box 2, Station H
Los Angeles, Calif.

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Woodson Oil Co. 1 E. L. Jennings, Sec. 6, ELRR Sur., dry, TD 2,776 ft., elev. 1,719 ft., Caddo 2,734 ft.

Woodson Oil 1 R. C. Morris, P. S. Hardy Sur., A-585, dry, TD 3,614 ft., elev. 1,558 ft., Caddo 2,505 ft., Ellenburger 3,376 ft.

Jack County: F. Kirk Johnson 1-A Craft, Sec. 2,723, TE&L Sur., dry, TD 2,815 ft.

Lebus Bros. 1 Fannie Ainsworth, Carl Almgren Sur., A-1,224, dry, TD 2,412 ft.

Russell Maguire 1 Ferguson, Sec. 2,729, TE&L Sur., dry, TD 5,018 ft.

J. C. Man Jr. 1 J. W. Hill, T. Toby Sur., A-857, dry, TD 3,905 ft.

Warren Petroleum Corp. 1 G. L. Jones, E. O. Allbritton Sur., dry, TD 5,576 ft., conglomerate 4,852 ft.

Jones County: Jack Drilling Co. et al 1 M. T. Hateries, Sec. 197, BBB&C Sur., dry, TD 3,312 ft.

Montague County: Johnny Clingingsmith 1 Pearl Jones, Wm. Donochoe Sur., A-178, dry, TD 2,911 ft.

Jack Grace Production Co. 2 C. McCall, ETRR Sur., A-235, dry, TD 5,891 ft.

Taylor County: Gilchrist Drilling Co. 1 Jessie Brown, D. T. Bruce heirs Sur. 135, dry, TD 2,712 ft.

Gilchrist Drilling 2 Bowles Est., Sec. 135, D. T. Bruce Heirs Sur., dry, TD 4,166 ft.

H. A. Horwitz 1 W. F. Rogers, 55-16-T&P, dry, TD 2,530 ft.

Robinson-Puckett, Inc. 1 I. N. Wilkinson, J. Gillespie Sur., dry, TD 4,693 ft.

Young County: W. C. Bockhoff Trustee 1 C. C. Burton, Blk. 213, TE&L Sur., dry, TD 940 ft.

Cox Drilling Co. 1 W. B. Dennis, Z. A. Zime Sur., A-1,862, dry, TD 4,462 ft., Caddo 4,401 ft.

Oil Hunters, Inc. 1 W. P. Burch, Wm. Porter Sur., A-225, dry, TD 4,789 ft., elev. 1,196 ft., conglomerate 4,289 ft.

Taubert & Harper 1 Prideaux, Tynes Sur., A-274, dry, TD 3,560 ft.

Ward & McCullough 1 T. J. McBride, Sec. 98, TE&L Sur., dry, TD 5,075 ft.

Mississippi

Gas Discovery Appears Evident in Monroe

JACKSON.—In Monroe County, Mississippi, approximately 3½ miles west of Aberdeen and 6 miles northeast of Muldon field, a new gas discovery seems to be assured at the Shell Oil Co. 1 Mrs. Lee Harrington, Section 25-14s-6e. On 28-minute drill-stem test of the Hartselle section at 3,514-51 ft., using ⅜-in. bottom and ¼-in. top chokes, the well flowed an unestimated amount of dry gas with top pressure building up to 1,040 psi. Recovery from the test was 470 ft. of gas-cut mud. Bottom-hole pressure was 1,250 psi. flowing and 1,625 psi. shut in. Hole was then drilled to 3,578 ft. and another test was run at 3,562-78 ft. Tool was left open for 62 minutes with top pressure only 2¼ psi. Recovery from this test was 100 ft. of gas-cut mud and 270 ft. of salt water. At last report operators were drilling ahead below 3,712 ft. This is the most encouraging development in the Paleozoic area since the Muldon field discovery well was completed. The completion of several dry wildcats in the basin had slackened interest to a certain extent. It is understood that this well was drilled on seismic information and should encourage others to follow their work with drilling.

In the extreme southwest part of Franklin County, Mississippi, final completion test has not been run on the Gulf Refining Co. 3 N. W. McCraine, Section 6-4n-1e, prospective new Wilcox discovery. It will be recalled that this test was perforated 4,728-29 ft. and 4,716-25 ft. opposite Wilcox sand which carried shows of oil. During the past week, a heater-treater was installed and the well was flowed on 11/64-in. choke. The well was shut in after the heater-treater had been filled and 32 bbl. of oil had been produced. Tubing pressure ranged from 60 to 90 psi. Final test will probably be run in the next few days.

In Hiwannee field, Wayne County, Mississippi, Gulf Refining Co. completed 2 wells recently. The northeast offset to the discovery well was completed from perforations 9,000-05 ft. and 9,006-11 ft. opposite Lower Cretaceous sand. On completion test this well pumped 27 bbl. of 37.2°-gravity oil plus 115 bbl. of water per day. One-half mile north of the discovery well, the Chapman-Jones Unit A was completed as a flowing well from Lower Cretaceous sand. On potential test the well flowed 149 bbl. of 36.7°-gravity oil plus 4.8 per cent b.s. and w. per day through ⅛-in. choke with tubing pressure 300 psi.

MISSISSIPPI WILDCAT FAILURES

Adams County: Dave Gammill-L. Cashion Co. 1 Lynwood-Hightower, Sec. 49-8n-1w, dry, TD 6,710 ft.

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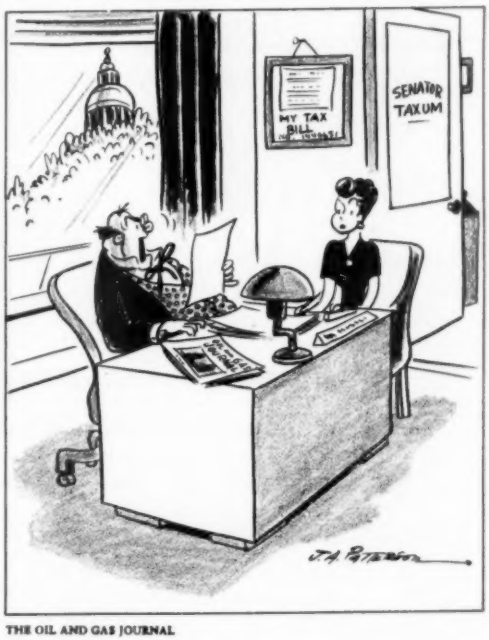

THE OIL AND GAS JOURNAL

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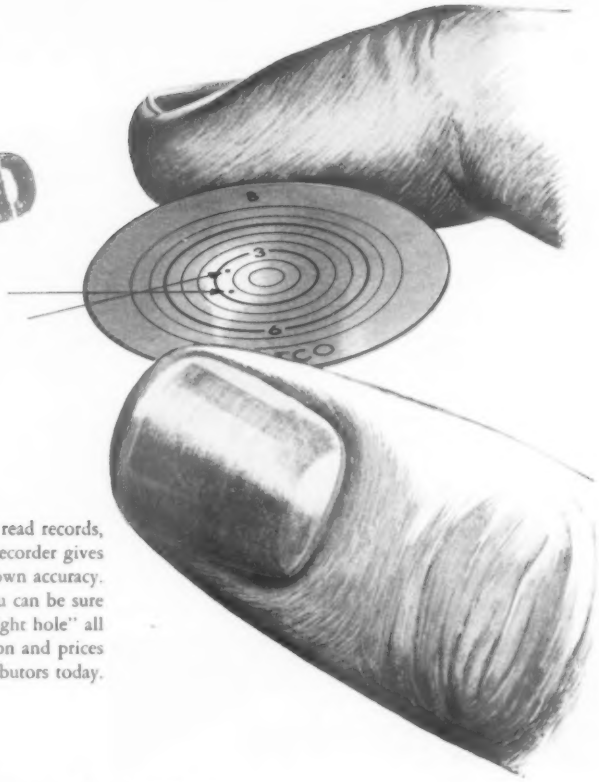

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Kemp Drilling Co. 1 C. F. Borger, Sec. 44-6n-2w, dry, TD 6,804 ft.

ALABAMA WILDCAT FAILURES

Monroe County: Sterrett B. Proctor 1 J. E. Dusenberry, Sec. 15-5n-63, dry, TD 5,517 ft.

Canadian Fields

Good Discoveries Recorded In Western Canada Areas

CALGARY.—During the past 7 days five exploratory wells chalked up either discovery of oil or gas, or gave up encouraging showings in western Canada. Four of those ventures are in Alberta, while the other is in Saskatchewan.

The Saskatchewan discovery this week was in the west sector of that province, near the town of Kerrobert, 10 miles north of Buffalo Coulee oil wells and 14 miles northwest of Coleville oil producers. The venture, owned by Canada Southern Oils, Ltd., is the fifth crude oil strike on that company's government permit lands in that general region of Saskatchewan. The other discoveries were made at Coleville, Eureka, Driver and Buffalo Coulee.

The discovery well, Canada Southern 7-10 Onward on LSD 7, 10-34-24w3, is 30 miles east of the Alberta border and 8 miles west of Kerrobert. The well gave up 14 to 15°-gravity crude oil during drill-stem test in the Banff sand at 2,664 ft. Production string of casing has been set.

Great Plains Development of Canada reported details of its wet gas discovery well in the Wayne area of southern Alberta. This venture, Great Plains-Socony 15-13 Wayne is on LSD 15, 13-27-20w4.

Drill-stem tests in the Cretaceous formation, down to 4,518 ft., flowed gas at rates ranging up to 4,020,000 cu. ft. daily and gave up to 40 ft. of grassy oil recovery. Analysis of the drill-stem test gas indicated recovery in excess of 40 bbls. of propane and higher fractions per million cu. ft. of gas.

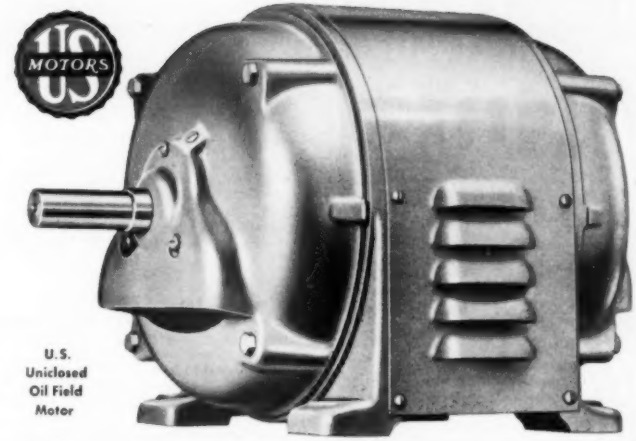
At Rochester, some 20 miles north of Redwater oilfield, a group of four Canadian independents found a multi-zone gas producer.

The well, Anglo 1 Rochester on LSD 2, 12-62-23w4, found gas during drill-stem tests in the Blairmore, glauconitic sand and D1 zone of Devonian, at rates in excess of 2,500,000 cu. ft. daily from some of the zone. Hole is being deepened.

At Cold Lake, north of Bonnyville, in northeast Alberta, New Continental Oil Co. of Canada gave up indications of possible heavy crude oil discovery in the Colony sand horizon and crew this week ran string of production casing for further tests. During drill-stem tests the well, Continental 1 Bonnyville on LSD 16, 25-63-5w4, did not give up free oil, so it is too early to yet evaluate the strike.

Pascar Oils, Ltd., Winnipeg independent, reports that its Madison limestone oil discovery well in the Coulter area of southwest Manitoba, 3 miles north of the United States border, has been swabbed at a rate exceeding 20 barrels per hour. The strike was made during the later part of October, and company officials now have plans under consideration for further drilling in that area.

The discovery well, Pascar 1 Westover, lies in LSD 1, 21-1-27w1, 9 miles west-northwest of California Standard's Waskada oil find and 15 miles east of the Saskatchewan border. The Madison oil production came in



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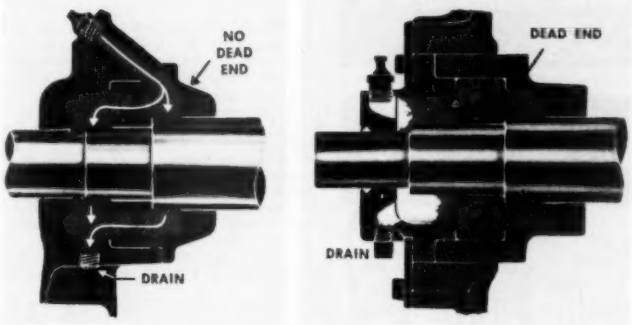

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around 3,201-11 ft. Gravity of the oil is 34°. No water showed during initial swabbing operations.

CANADIAN SUCCESSFUL WILDCATS

Leduc Consolidated-Socony 2 Chancellor on LSD 14, 13-25-21w4, TD 4,915 ft.

CANADIAN WILDCAT FAILURES

Texaco A-1 Blueberry Mountain, on LSD 7, 8-82-7w6, TD 3,747 ft.

Texaco A-1 Pigeon Hills, on LSD 16, 2-48-1w5, TD 7,500 ft.

Allenbee-Peak & Associates Can. Southern 1 Schuler, on LSD 2, 22-15-1w4, TD 5,719 ft.

EASTERN CANADA

Ontario.—In southwestern Ontario, Anchor Petroleums is moving drilling rig for its first well on a 715-acre lease, to be drilled under agreement with Western Ashley Minerals, Ltd. Anchor receives a 50 per cent interest in the acreage in return for a cash outlay and a limited participation 3-well drilling commitment. On completion of the three wells, Anchor and Western Ashley will continue joint development of the property.

Eastern Texas

Commercial Production Seen For Morris County

DALLAS.—Prospects of commercial production for Morris County were reported good at B. G. Byars and associates' second test, the 2 Paul Pewitt, located 9 miles north of Omaha and about 6 mile northeast of the 1 Pewitt, which was dry.

Top of the Paluxy sand was reported at 4,712 ft. First drill-stem test at 4,696-4,715 ft. recovered 245 ft. of oil and 205 ft. of heavily oil-cut mud. Time was 30 minutes. Second test, open 1 hour, at 4,702-15 ft. returned 1,100 ft. of 21°-gravity oil. Bottom-hole flowing pressure was 500 psi. and 15-minute shut-in pressure reached 2,000 psi. Operators cored ahead to 4,744 ft. and tested with packer at 4,715 ft., but recovered salt water.

In Navarro County, J. L. Collins and Co. 1 Greenlee, west outpost to South Kerens field, developed salt water in the Woodbine on production test through perforations at 3,391-96 ft. The well had promises of production when a drill-stem test at 3,378-91 ft. had oil at the surface in 12 minutes.

Humble Oil & Refining Co. 1 First National Bank of Corsicana, deep wildcat 8 miles south of Kerens, was drilling in salt and anhydrite at 12,408 ft. at last report.

In Shelby County, Atlantic Refining Co. 1 Frost Lumber Co. was coring below 6,563 ft. after taking a number of side-wall samples from 1,430-55 ft.

Pure Oil Co. 8-D Swain, wildcat northeast of Van in Van Zandt County, was coring ahead below 10,850 ft. Projected depth was 12,000 ft.

EAST TEXAS (DISTRICTS 5 AND 6) WILDCAT FAILURES

Angelina County: Trans-American Petroleum Corp. 1 Ray Hambrick, J. A. Prado Sur., 1 mile SE Burke, dry, TD 5,516 ft.

Camp County: J. B. Stephens Jr. and A. O. Phillips 1 Sam Bell, Mary Mays Sur., 3 miles SE Pittsburgh, dry, TD 8,613 ft.

Harrison County: Humble Oil & Refining Co. 1 Henry Hugh, E. M. Fuller Sur., A-7, 3 miles S Karnack, dry, TD 6,503

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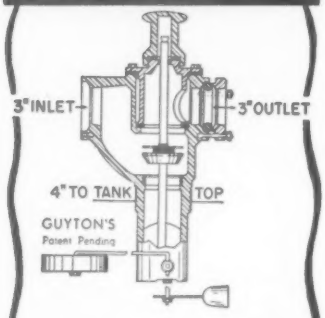

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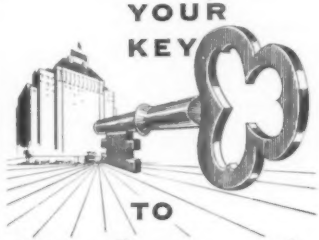

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ft., Fredericksburg 2,607 ft., Paluxy 2,972 ft.

Wood County: Edson Petroleum Co. 1 Earnest Lee, W. Caison Sur., A-123, 2 miles SW Winsboro, dry, TD 4,180 ft.

Permian Basin

Big Yoakum Discovery Completed in Devonian

MIDLAND.—Amerada Petroleum Corp. 1 Weems, northwest Yoakum County discovery, has been completed for a daily potential of 1,934 bbl. of oil. Potential was based on an actual flow of 967 bbl. in 12 hours through ¾-in. choke, from perforations in the Devonian at 11,773-860 ft. Gravity was 43.4° and gas-oil ratio was 178 cu. ft. There was no formation water and completion was without acid.

The discovery also showed for production from the Mississippian limestone. Drill-stem test in that formation at 11,020-95 ft. flowed 205 bbl. of oil in 2½ hours.

Honolulu Oil Corp. has taken over operations at Ryan, Hays & Burke 1 Fillingim, Yoakum wildcat 10 miles southwest of Plains and 8 miles south of Amerada 1 Weems, and will drill to the Devonian. At last report the well was drilling below 11,040 ft., in the Mississippian, topped at 10,682 ft. on elevation of 3,746 ft., or minus 6,936 ft. Mississippian top in the 1 Weems was minus 7,147 ft.

In southeast Andrews County, Shell Oil Co. 1-A-1 University recovered 150 ft. of gas-cut mud, 270 ft. of oil and gas-cut mud and 150 ft. of heavily oil-cut mud on a 2½-hour test in the Devonian at 10,750-825 ft. It was drilling ahead.

Cabot Carbon Co. and others 1-A University, Reagan County wildcat southwest of Big Lake, had gas at the surface in 40 minutes and recovered 95 ft. of gas-cut mud, with no oil, on a 2-hour test of the Fusselman section at 9,380-9,462 ft. Top of the Fusselman was reported at 9,385 ft., minus 6,738 ft.

J. D. Wrather Jr. 1 G. T. Hall, southwest Ector County discovery in 7-B15-PSL, completel from the Fusselman section at 9,830-65 ft., flowing 173 bbl. of oil a day through 24/64-in. choke. The well also showed for possible production from the Devonian, tested between 8,808-36 ft.

In Kent County, General American Oil Co. 1 Atkins Unit, southeast of reef production in Salt Creek field, topped the reef pay at 6,619 ft., then flowed 7 bbl. of oil into pits in 1 hour and 25 minutes on drill-stem test from 6,621-59 ft. The well unloaded oil while pipe was pulled, and there was no water in recovery.

First drill-stem tests in the Ellenburger at Gulf Oil Corp. 1 McElroy Ranch, Upton County Devonian and Ordovician discovery, gave promises of oil in that formation. Top of the Ellenburger was 11,602 ft., and minus 8,991 ft. A 3-hour test at 11,625-80 ft. developed some gas in the pipe, 270 ft. of heavily gas-cut mud and 5 ft. of oil and mud.

Gulf Oil Corp. 1 Mitchell Bros., Presidio County wildcat, was drilling below 15,315 ft.

Gulf and Jack Frost 1 Northrup, Reeves County wildcat, drilled cement out between 11,623-69 ft. and was washing down at 11,669-753 ft.

Gulf 3 John Haggard, north outpost to Quinduno field of Roberts County, Texas Panhandle, ran a 2-hour drill-stem test in top of the Douglas sand at 6,227-75 ft. Gas reached the top in 24 minutes, estimated at 287,000 cu. ft. daily. Recovery was 430 ft. of gas-cut drilling mud. It was to be drilled ahead.

Gulf 1-A McCuistion, southeast outpost to the same field, made an estimated 3,000,000 cu. ft. of gas daily on a drill-stem test from 3,932-4,008 ft.

WEST TEXAS (DISTRICTS 7-C AND 8) SUCCESSFUL WILDCATS

Andrews County: Phillips Petroleum Co. 1-KK University, 22-11-University, TD 10,051 ft., elev. 3,318 ft., pay 8,020 ft., IP 142 bbl. 42°-gravity oil, 18/64-in. choke, TP 140 psi., GOR 801 cu. ft.

Phillips 1-QQ University, 48-13-University, TD 3,153 ft., elev. 3,241 ft., Yates 2,945 ft., IP 82 bbl. 44°-gravity oil, 10/64-in. choke, TP 250 psi., GOR 5,219 cu. ft.

Ector County: Phillips Petroleum Co. 1-B Millard, 24-B15-PSL, TD 8,677 ft., elev. 2,915 ft., dual completion; top Waddell 8,285 ft., pay 8,300 ft., IP 452 bbl. 42°-gravity oil, ½-in. choke, GOR 606 cu. ft., CP 160 psi.; Ellenbugrer 8,600 ft., IP 1,054 bbl. 42°-gravity oil, ½-in. choke, GOR 486 cu. ft., TP 350 psi.

Midland County: Plymouth Oil Co. 1-A Foster, 11-41-T2S-T&P, TD 11,223 ft., elev. 2,894 ft., Strawn 10,550 ft., pay 10,570 ft., IP 299 bbl. 47°-gravity oil, ½-in. choke, GOR 1,703 cu. ft., TP 225 psi.

Runnels County: Rowan Drilling Co. 1 G. H. Ashton, H&GN Sur., A-282, TD 4,810 ft., elev. 1,744 ft., Odom lime 4,524 ft., IP 122 bbl. 38°-gravity oil, 16/64-in. choke, TP 100 psi., GOR 525 cu. ft.

WEST TEXAS (DISTRICTS 7-C AND 8) WILDCAT FAILURES

Coke County: Kewanee Oil Co. Wendland, Sec. 23, Casimera Rubio Sur., dry, TD 6,318 ft., in the Ellenburger, elev. 1,803 ft.

Crockett County: Continental Oil Co. 1-C Harris, 4-BB2-Francis Boren Sur., dry, TD 9,210 ft., elev. 2,805 ft., Strawn 8,024 ft., Simpson 8,500 ft., Ellenburger 8,741 ft.

Ector County: Hanley Co. 1 C. V. Headlee, 39-41-T1S-T&P, dry, TD 11,178 ft., elev. 2,990 ft., Wolfcamp 9,545 ft., Strawn 10,635 ft.

Glasscock County: Phillips Petroleum Co. 1-C McDowell, 31-33-T2S-T&P, dry, TD 2,766 ft., elev. 2,552 ft., Yates 1,690 ft.

Kent County: Superior Oil Co. 2-7 Wood, Sec. 7, John Rodman Sur., dry, TD 7,576 ft., elev. 2,112 ft., Mississippian 7,325 ft., Ellenburger 7,567 ft.

Pecos County: Big West Drilling Co. et al 1 R. Levy, 104-8-H&GN, dry, TD 6,617 ft., elev. 2,464 ft., Devonian 6,580 ft.

W. R. Weaver 1 Overton Black, 5-114-GC&SF, dry, TD 2,993 ft., elev. 2,828 ft., Yates 2,838 ft.

Runnels County: John J. Eisner 1 McDaniel, Blk. 21, A. Sosoya Sur. 515, dry, TD 3,901 ft.

Bert Fields 1 Kirby Robinson, T. M. Fowler Sur., dry, TD 4,953 ft.

Mar Tex Realization Corp. 2 W. L. Bryan, W. H. Smith Sur. 599, dry, TD 4,994 ft.

Roark, Hooker & Hill 1 Harris Davenport, J. J. Ximenez Sur. 265, dry, TD 4,318 ft.

Rowan Drilling Co. 2 G. H. Ashton, H&GN Sur. A-283, dry, TD 4,555 ft.

Schleicher County: G. W. Stake 1-B J. F. Runge, 67-M-GH&SA, dry, TD 5,848 ft., elev. 2,160 ft., Palo Pinto 5,028 ft., reef 5,768 ft.

Ward County: M. T. Stallter 1 C. Woods, Sec. 5, W. J. Turner Sur., dry, TD 2,552 ft.

Yoakum County: Sinclair Oil & Gas Co. 1-A

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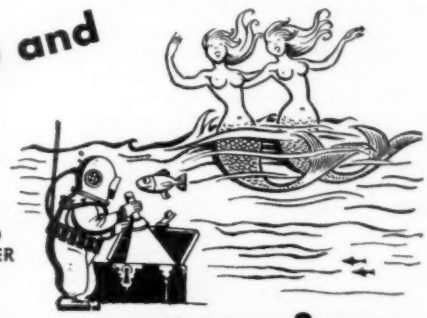

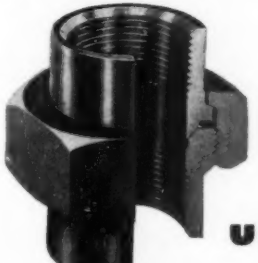

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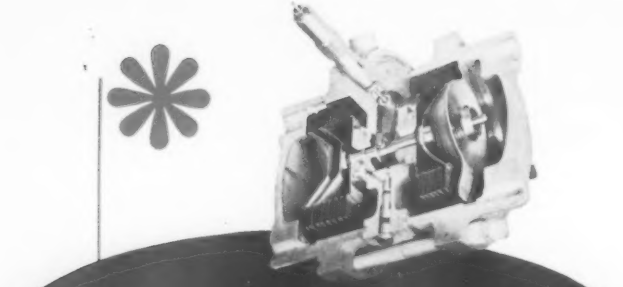

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Sinclair 1 Elwood Fouts, 575-D-J. H. Gibson, dry, TD 11,400 ft., elev. 3,669 ft., Pennsylvanian 10,525 ft., Mississippian 10,675 ft., Devonian 11,350 ft.

TEXAS PANHANDLE (DISTRICT 10) WILDCAT FAILURES

Gray County: Gulf Oil Corp. 1 Franklin, 44-A6-H&GN, 19 miles SE Pampa, dry, TD 4,000 ft., stratigraphic test.

Hartley County: Birdwell 2-A Houghton, 210-14-SCL, dry, TD 4,106 ft. in pre-Cambrian, elev. 3,873 ft.

Hemphill County: Sinclair Oil & Gas Co. 1 Isaacs, 114-41-H&TC, 10 miles SE Canadian, dry, TD 13,500 ft., elev. 2,374 ft.

SOUTHEAST NEW MEXICO

Sun Oil Co. 1 Harper-Federal, Lea County prospect, swabbed 50 bbl. of oil and 9 bbl. of fresh water in 11 hours, with fluid level going from 7,000 to 9,000 ft. Previous swabbing recovered 75 per cent oil and the balance wash water, and lowered the fluid level from 6,000 to 10,000 ft. Shut in overnight, it rose to 7,000 ft. Additional acidizing was planned.

Gulf 1 Federal-General American Oil Co., Eddy County wildcat, had total depth at 11,261 ft. and was preparing to core ahead.

Los Nietos Oil Co. 1 State-Gross extended East Cap Rock field ½ mile west. Completion was for 937 bbl. of oil a day through ¼-in. choke from pay at 11,268-95 ft. Completion was without acid.

East of the Lovington area, Cities Service Oil Co. 1-AF State was drilling below 10,078 ft.

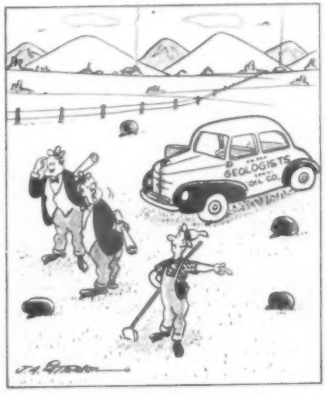
New exploration work in Lea County included a deep wildcat 3½ miles southeast of Tulk-Wolfcamp field. Texas Pacific Coal & Oil Co. 1 Lane-Mill Unit, 32-15s-22e, will be drilled to 13,700 ft.

SOUTHEAST NEW MEXICO WILDCAT FAILURES

Chaves County: Stanolind Oil & Gas Co. 1 Polecat Canyon Unit, 34-10s-31e, dry, TD 11,750 ft., elev. 4,341 ft., Pennsylvanian 9,212 ft., Mississippian 10,910 ft., Devonian 11,605 ft.

Vincent & Welch, Inc. 1 Fred M. Cassidy, 27-14s-27e, dry, TD 9,336 ft., elev. 3,452 ft., Devonian 8,550 ft., Ellenburger 9,220 ft.

Eddy County: Southern California Petroleum



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W. F. Swain 1 Atwood, 11-16s-35e, dry, TD 226 ft.

Texas Gulf Coast

North Blue Ridge Field Records East Extension

HOUSTON.—Absolute open flow potential has been reported by J. R. Butler et al on 1 Mayfair Park, Inc., 3,300-ft. east extension of North Blue Ridge Vicksburg field to mark the first producer for the field on the Harris County side. Open flow potential shows the well to be good for 11,000,000 cu. ft. of gas per day with production of 62.1°-gravity distillate under gas-liquid ratio of 23,000-1, tubing pressure of 2,719 psi. Final perforations were reported with 48 shots at 7,785-97 ft. Hole is bottomed at 7,855 ft. with 5½-in. production string cemented at 7,840 ft. Well lies 3,300 ft. east of 4 Evans-Bailey, nearest producer, one of 4 oil producers in the Evans-Bailey tract and drilled by Johnny Mitchell. Current completion is on the TTRR Co. Sur., A-1023, Section 15, 400 ft. northeast of the Harris-Fort Bend County line.

Three miles northwest of Needville gas production and 4 miles northwest of Needville Townsite, Fort Bend County, Union Producing Co. has filed for permit to directionally drill 1 Brinkmeyer as a 4,600-ft. wildcat, just 100 ft. southeast of an old abandoned 6,131 ft. dry hole. The old failure was drilled by McKay in December 1944. New venture is on the H&TC RR Survey, A-243.

Arkansas Fuel Oil Co., of Shreveport, have filed for deep test 1 J. H. Prigden, wildcat, DeWitt County, approximately 4 miles northeast of Thomaston. New wildcat location is on the SA&MG RR Survey, A-446. Wildcat is proposed to total depth of 8,500 ft.; operations will begin immediately.

One mile west-northwest of nearest oil production in Fulshear field and 2½ miles south of Katy in Fort Bend County, Sunray Oil Corp. has abandoned 1 Clyde Nelson after testing gas shows. Firm made hole to 7,812 ft. and cemented 5½-in. casing on bottom for completion attempt. Perforations at 7,691-97 ft. blew small amount of gas for about 4 hours on 8 hour 47 minutes drill-stem test. After block squeeze, test on re-perforations at 7,422-28 ft., recovered 6,000 ft. of gas-cut salt water, 500 ft. of water cushion, and 300 ft. of rat-hole mud. Well was abandoned after cement plug was spotted 7,190-200 ft. with 95 sacks.

TEXAS GULF COAST (DISTRICTS 2 AND 3) SUCCESSFUL WILDCATS

Calhoun County: Western Natural Gas Co. 1 St. San Antonio Bay Tr. 49, San Antonio Bay, TD 9,515 ft., open flow 3,400,000 cu. ft. of gas per day, plus 203.5 bbls. of 56.9° - gravity distillate, gas - oil ratio 12,500:1.

Jackson County: Sam G. Harrison 1 Edwin L. Whisler et al, John Davis Survey, A-16, TD 6,609 ft., 69 bbl. of oil per day on 5/64-in. choke, gas-oil ratio 280:1.

TEXAS GULF COAST (DISTRICTS 2 AND 3) WILDCAT FAILURES

Brazos County: Liberty Work-Over & Drilling Co. 1 P. G. Longmire, Crawford Burnett Survey, TD dry, 3,043 ft.

DeWitt County: LaGloria Corp. 1 Mamie Heard, Wm. Dearduff Sur., dry, TD 8,010 ft.

Sun Oil Co. Bluntzer heirs, John McCrabb League and J. F. Kemper Sur., dry, TD 9,252 ft.

Fayette County: Triple A. Producing Co. B-1 Otto Steinhauser, James Parrott Sur., dry, TD 2,379 ft.

Goliad County: 2nd M. E. Andrews Ltd.-Dallas Huskey et al 1 R. F. Wilkerson, James Calaghan Sur., A-81, dry, TD 4,500 ft.

Dudley T. Daugherty et al 1 J. M. Pettus, C. M. Hyde Sur., dry, TD 5,132 ft.

Jackson County: Gravis & Mitchell 1 J. H. McColloch, T. J. Reed Sur., A-63, dry, TD 6,000 ft.

Harris County: Oil & Chemical Products, Inc. 1 Oil & Chemical Products, Inc., H&TC RR Survey, A-445, dry, TD 7,802 ft.

Polk County: Petroleum Management Co. 1 Ed Duff, Augustine Viesca Sur., A-77, dry, TD 4,255 ft.

Victoria County: 2nd M. E. Andrews, Ltd., 1 Robert and Henry Alex, Manuel Zepeda Sur., dry, TD 4,516 ft.

Taylor Oil & Gas Co. 1 Paul G. Conrad unit, J. Ricker Sur., A-284 dry, TD 5,502 ft.

L. L. Woodman 1 Grace Gaffney, Juan Flores Sur., A-29, dry, TD 5,800 ft.

Louisiana-Ark.

Nacatoch Discovery Seen At Grogan Field Well

SHREVEPORT.—R. P. Bufkin has strong indications of a Nacatoch sand discovery in Grogan field, DeSoto Parish, western central Louisiana. The oil gravity is 48° with apparently no formation water. Official test is to be taken shortly. The sand was hit at 1,203 ft. and the well was taken to total depth of 1,245 ft. An estimated 42 ft. of saturated sand was logged. Four more locations have been staked in the area as a result of this indicated discovery. First production from the Nacatoch in this area lies 8½ miles southwest. That discovery was offset in three directions and three other tests were drilled in the area with only one getting a show. The Nacatoch formation wedges out to the south in this area, as interpreted from previous wells correlated.

The month of October saw four new discoveries for North Louisiana. The Texas Co. completed its 1 J. C. Williams, Jr. in the Massive anhydrite opening a new pool in the Keithville area, Caddo Parish. Hunt Oil Co. et al completed an oil discovery in Catahoula Parish at 70 Louisiana Delta for 133 bbl. of oil daily from the Wilcox opening West Mitten Lakes field. Hunt also completed a La Salle Parish discovery in the Wilcox for 111 bbl. daily, opening Long Slough field. Carter Oil Co. completed 1 Crystal in Bossier Parish for 238 bbl. of condensate daily opening a new pool on the Cotton Valley flank.

Arkansas.—Kirby Petroleum Co. is drilling ahead at 2,936 ft. at 1 Southern Co., C SE SW NW 18-16s-14w, wildcat 2¾ miles west of Calion townsite in Union County, with production indicated on a 11-minute drill-stem test in the Tokio sand from 2,595-2,611 ft. Recovery was 400 ft. of oil, no water.

LOUISIANA WILDCAT FAILURES

Bossier Parish: Atlantic Refining Co. 2 Crystal Oil & Refining Co., C NW SE SE 6-20n-13w, dry, TD 2,192 ft.

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Catahoula Parish: Lee Ware, Jr. and Barnett Serio 1 Trisler, 4,600 ft. E and 660 ft. S NWc 22-5n-6e, dry, TD 6,512 ft.

Franklin Parish: Bering Oil Co. 1 Mock, C SW NW SE 16-15n-7e, dry, TD 4,013 ft.

ARKANSAS SUCCESSFUL WILDCAT

Union County: Carter Oil Co. 1 Wooley, 532 ft. S and 650 ft. W NEc 28-18s-17w, pumped 63 bbl. of oil from Tuscaloosa at 3,104-08 ft., TD 4,200 ft. (discovery tentatively called Schuler, South pool).

ARKANSAS WILDCAT FAILURE

Lafayette County: McAlester Fuel Co. et al 1 Burton Bros. "A," C NE SW NE 36-17s-25w, dry, TD 9,487 ft.

Southwest Texas

Gas Discovery Potentialed In Jim Wells County

CORPUS CHRISTI.—A new gas discovery, 1 N. G. Norton, in Mary area, Jim Wells County has been potentialed by South Texas Oil & Gas Co. New discovery flowed an estimated 37,000,000 cu. ft. of gas per day through perforations shot at 4,670-80 ft., plus 12 bbl. of distillate per million cu. ft. of gas, on open flow. On open hole test at 4,765-84 ft., recovery was dry gas through ¼-in. choke, under 340 psi. working pressure. Results of test perforations shot at 4,765-84 ft., on drill-stem test, indicated 15 ft. of gas sand. Company used a ¼-in. choke for the test, under working pressure of 340 psi., with bottom-hole pressures; open 2,200 psi. closed 2,200 psi. Seven minute drill-stem test at the same interval with packer set at 4,765 ft., recovery was 30 ft. of distillate plus some gas, bottom-hole pressures were: open 2,200 psi., closed 2,250 psi. Company bottomed hole to total depth of 5,765 ft., 5½-in. production casing was cemented to 4,900 ft. Operations are approximately 4 miles northeast of Alice, in Los Presnos de Abajo Grant, Section 6-A.

Open hole test of Alsaka Steamship Co. and Newman Bros. Drilling Co.'s G-3 South Texas Syndicate, produced a dual gas sand completion from the Wilcox sand at 5,313-19 ft., and basal Wilcox at 6,134-52 ft. Open hole test in Wilcox through perforations shot at 5,313-19 ft., flowed 17,000,000 cu. ft. of gas per day, plus 16 bbl. of distillate per million cu. ft. of gas per day. Test was completed under a 2,100 psi. shut-in pressure. Test of basal Wilcox was made through perforations shot at 6,134-52 ft., flow registered 18,000,000 cu. ft. of gas per day, plus 10.5 bbl. of distillate per million cu. ft. of gas. Firm bottomed hole to total depth of 6,152 ft. and cemented 5½-in. production casing to 6,152 ft. Wildcat is on the BS&FS Survey, Section 13.

S. H. Howell, Alice operator, is completing the 1 Emil E. Pillack, extension test to Bailey field, approximately 8 miles northeast of Alice, Jim Wells County. Operator test perforations shot at 3,948-73 ft., recovery was 21,000,000 cu. ft. of gas per day, on open flow. New discovery was originally bottomed to total depth of 6,000 ft.; however, operator plugged back to make completion at the 3,948-73 ft. interval. Cores pulled at 3,960-75 ft., recovered gas in top and oil in bottom of the core. Information concerning casing settings has not been released by operator. Discovery is on Richard King Farm Lots, Block A.

New sand discovery, the 2 K. J. Kivlin

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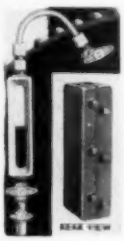

. . . because they are made of tougher metal, thicker glass, and because they are factory tested. Inferno Bronze Reflex gauges tested to 2000 lbs. for working pressure up to 350 lbs.; Inferno Stainless Steel Reflex Gauges tested to 1000 lbs. for working pressure up to 2500 lbs. Write for Bulletin No. 19B.

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et al has been completed by Ritchie and Mumme Oil Co. of Alice. Firm potentialed the new discovery through perforations shot at 3,269-79 ft., and test flowed an estimated 89.32 bbl. of oil per day through 9/64-in. choke. Potential developed a tubing pressure of 100 psi. completion registered a gravity reading of 25.0°, gas-oil ratio 98-1. Perforations shot at 3,300-36 ft. interval recovered 140 bbl. of pipe-line oil per day, on 9/64-in. choke, under 120 to 180 psi. tubing pressure, casing sealed. Hole is bottomed to total depth of 3,845 ft., 6½-in. production string is cemented to 3,341 ft. 2-in. tubing is swung to 3,243 ft. Production is called in the 3,300-ft. sand section with top pay at 3,266 ft. Pipe-line connection to new discovery is with Scurlock Oil Co. Operations are on the K. I. & I. Kleberg County Improvement and Development Co., Section 39, Block 8, Kleberg County.

SOUTHWEST TEXAS (DISTRICTS 1 AND 4) WILDCAT FAILURES

Atascosa County: Rowan & Hope & E. W. Gill 1 Charles H. Brown, John Rugley Sur. A-752, dry, TD 5,820 ft.

Stanolind Oil & Gas Co. 1 Chester Coble, Luciano Valverdo Sur., dry, TD 5,836 ft.

Sid Katz 3 D. D. Heinen, Carlos Perez Sur., dry, TD 1,423 ft.

Duval County: Hamon, Cox & Coates 1 Leila Peters "13688," G. J. Reynolds Sur., dry, TD 4,810 ft.

Frio County: Milam Drilling Co. 1 N. O. Green, Albert Fisher Sur., A-317, dry, TD 4,827 ft.

Guadalupe County: Gasoline Prod. Co. 1 Henry Seay, L. Mansola Sur., A-29, dry, TD 2,235 ft.

Magnolia Petroleum Co. 1 Francis Baker, Harriet Cottle Lge., dry, TD 4,705 ft.

Jim Hogg County: Daubert and Achning 1 P. B. Harbinson, E. Sordo Grant Sec. 9, dry, TD 2,551 ft.

McMullen County: Kirkwood & Morgan, Inc. 1 H. D. and Sam Countiss, Thomas J. Hughes Sur., dry, TD 6,022 ft.

Nueces County: Geo. E. Farenthold 1 Alfred Koenig, Casa Blanca Grant, dry, TD 5,860 ft.

Heep Oil Corp. et al 1 W. R. Gillum, Palo Alto Subd., Sec. 187, dry, TD 7,317 ft.

Selby Walker Corp. 1 Edgar H. Linkenhoger, Roberts & White Subd., dry, TD 5,705 ft.

Starr County: Martin Shelly & Thomas 1 Margarita Pena de Gutierrez, El Puerto Ranch Partition, dry, TD 2,809 ft.

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South Louisiana

New Pay Opened in West White Lake Area

NEW ORLEANS.—In the West White Lake area, Vermilion Parish, Union Oil of California has opened a new pay at its 1 State 2118, through perforations 8,860-80 ft. Flowing on 10/64-in. choke, initial production was 296 bbl. of 37.8°-gravity oil daily under 1,475 psi. tubing pressure. Gas-oil ratio measured 686-1. Drilled to 12,692 ft. operator plugged back to 9,400 ft. for potential test after setting 5½-in. casing at 9,359 ft. Previous 12-hour drill-stem test, with 2-in. tubing set on packer at 8,835 ft., well flowed at rate of 310 bbl. daily, tubing pressure 1,500 psi., gas-oil ratio 610-1.

Union Producing Co. has estimated new pay for Bourg field, Terrebonne Parish, at its 2 Barrow, Section 38-17s-18e. Flowing through perforations 11,408-422 ft., well flowed 227 bbl. of 50.7°-gravity distillate plus 9,319,000 cu. ft. of gas daily on 5/16-in. choke under 4,168 psi. tubing pressure. Gas-oil ratio measured 41,502-1. Bottomed at 12,740 ft. well has 7-in. casing set at that point and 2⅞-in. tubing swing at 11,358 ft. Prior to taking production test, operator had perforated and squeezed at 11,794-795, 11,409-411 and 11,168-169 ft. zones to isolate the salt water.

In Lake St. Agnes area, Kemp Drilling Co. has completed its 1 Fisher, Avoyelles Parish, for 125 bbl. of 42°-gravity oil daily through 9/64-in. choke. Gas-oil ratio measured 200-1, with 440 psi. tubing pressure. Discovery, bottomed at 8,505 ft., 5½-in. casing 7,600 ft. and 2-in. tubing 7,360-ft., previously flowed at rate of 120 bbl. of oil daily through ⅜-in. top and ¼-in. bottom chokes under 650 psi. working pressure. Well is in Section 34-3n-5e.

A flow of 101 bbl. of distillate plus 27,000,000 cu. ft. of gas daily on 14/64-in. choke has been reported by F. A. Callery, Inc. at its 1 Home for Incurables et al, gas discovery in St. Charles Parish. Hole bottomed at 10,520 ft., sidetrack hole, flowed through perforations 10,407-11 ft. under 3,500 psi. tubing pressure. Originally drilled to 11,976 ft., operator then plugged back and sidetracked at 8,540 ft. Located in Section 1-13w-20e, new discovery is approximately 5 miles southwest of Hahnville townsite.

On drill-stem test, through ¼-in. by ⅜-in. chokes, Magnolia Petroleum Co., recovered 1,200 ft. of oil at its 1 Armas Sylvester, wildcat, in St. Landry Parish.

Bottomed at 10,838 ft., well flowed through perforations 10,805-807 ft. with working pressure registering 32 psi. Initial bottom hole flowing pressure was 2,250 psi., final 2,960 psi. Operator has squeezed the perforations

and reperforated 10,706-724 ft., had a good blow with tool open 35 minutes. Location is 5 miles southeast of Ville Platte in Section 139-5s-3e.

SOUTH LOUISIANA WILDCAT FAILURE

Plaquemines Parish: Humble Oil & Refining Co. 1 La. St. 2026 Bay Adams, USC&GS Sta. Bayou Cook, dry, TD 12,500 ft.

Oklahoma

Third Springer Sand Pool Opened in Garvin County

MAGNOLIA PETROLEUM CO. has completed its new Springer discovery well in western Garvin County with a flow of 566 bbl. of 38°-gravity oil in 24 hours through ½-in. choke. The well, 1 Duncan, NE NE SE 1-3n-4w, 6 miles southeast of Lindsay, opens the third Springer pool along the western flank of the Golden Trend development in that county. All are this year's discoveries. Others are the East Purdy pool, 2 miles to the southeast, opened by Phillips Petroleum Co. last May, and the Southeast Purdy pool, 3 miles further southeast, opened early in the year by Vickers Petroleum Co.

Production of the Magnolia discovery is from casing perforations at 9,010-62 ft. with top of the Springer at 9,013 ft. Hole is plugged back to 9,146 ft. from a total depth of 9,180 ft. where casing was run. Production was with a gas-oil ratio of 700 cu. ft. per barrel. Flowing pressure on the tubing gaged 250 psi.

Testing is under way at Sinclair Oil & Gas Co.'s new Bromide discovery well, 1 Community Smith, C SW NW 17-5n-4w, 5 miles north of Lindsay, in McClain County. Preliminary drill-stem test of casing perforations at 11,380-82 ft., made for water shutoff, got an oil flow of 25 bbl. the first hour after recovering water cushion, and filled 720 ft. with oil. These perforations were squeezed and additional perforations made at 11,240-242 ft. for another squeeze job, where a 2½-hour drill-stem test flowed 46 bbl. of oil the first hour and 47 bbl. the second hour after recovering cushion. Breakdown recovery was 590 ft. of oil. Total depth is 12,495 ft. with bottom of the casing at 12,169 ft. A series of drill-stem tests made through the Bromide zone while hole was being drilled showed for good oil production. Location is 2 miles northwest of the North Lindsay field and about the same distance southeast of the Northeast Bradley field.

Shell Oil Co. has run oil string in its deep wildcat, 1 Adams, C SE SE 6-9n-19w, 6 miles west of Dill, in western Washita County, where tests will be made of previously indicated oil production encountered in granite wash. The well, located 5 miles southeast of the Elk City field, was drilled to a total depth of 12,500 ft. Casing is bottomed through the granite wash zones to 11,475 ft.

W. H. Martgan and associates have indications of good Bartlesville production in their 1 Deyarman, SW NE NE 25-18n-1e, north offset to their recently completed lower Skinner-sand discovery well, 1 Ganes, located north of the abandoned North Coyle area in western Payne County. Bartlesville was topped at 4,449 ft., and a 2-hour drill-stem test at 4,450-57 ft. got gas in 25 minutes and recovered 550 ft. of clean oil and 140 ft. of oily mud. Hole is being deepened to the Wilcox, in which promising oil showings were found in the discovery well but which failed to make a well on production tests.

OKLAHOMA SUCCESSFUL WILDCATS

Beaver County: Deep Rock Oil Corp. 1 Shaddin "A," C NE NW 25-3n-24eCM, pumped 102 bbl. of oil from Morrow 7,316-22 ft., TD 8,431 ft.

Cleveland County: Randall R. Morton 1 Capehart, NW SW SE 14-8n-1e, flowed 300 bbl. of 41°-gravity oil from second Wilcox 6,271-79 ft., TD 6,279 ft.

Tulsa County: L. B. Hansen and George Hastings 1 Moore, SE NE NW 36-17n-14e, flowed 48 bbl. of oil from sand at 1,883-85 ft., 35° gravity, TD 1,885 ft.

OKLAHOMA WILDCAT FAILURES

Carter County: H. F. Gibson 1 Arnold et al, NW NW NW 27-5s-1w, dry, TD 5,659 ft.

Creek County: Simon & Bassett 1 Dill & Young, SW SE SE 13-18n-8e, dry, TD 3,055 ft.

Garvin County: Superior Oil Co. 1 Slay, C SW SW 27-4n-4w, dry, TD 9,900 ft.

Grant County: Youngblood & Youngblood 1 Bartlett, C SW NE 4-27n-8w, dry, TD 5,866 ft.

Jefferson County: Mack Oil Co. 1 Virtrees, SW SE NE 27-3s-4w, dry, TD 3,506 ft.

Kay County: Mazda Oil Corp. 1 Schmidt, SE SE NE 26-28n-1e, dry, TD 3,800 ft.

Logan County: James B. Templeton and C. J. Stafford 1 Grieschen, NW NW NW 23-19n-2w, dry, TD 5,483 ft.

Love County: Continental Oil Co. 1 Gant "A," SE SE SW 16-6s-1e, dry, TD 7,891 ft.

McClain County: The Texas Co. et al 1

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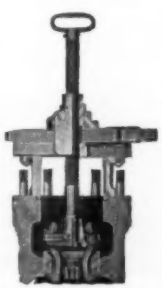

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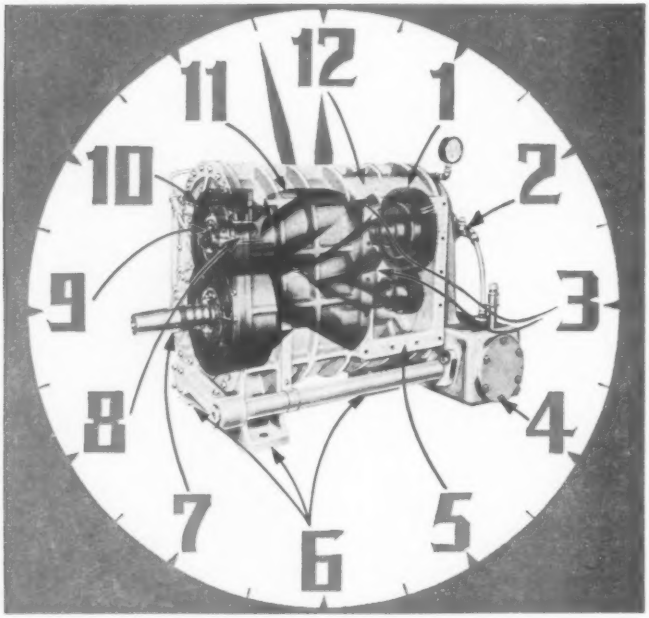

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Osage County: Sand Springs Home 1 Osage, SE SE SW 29-26n-7e, dry, TD 2,860 ft.

Payne County: J. G. Catlett 1 Stephens, NE NE NE 24-20n-4e, dry, TD 4,027 ft.

Appalachian-Ohio

Deep Logan Test Results in Dry Hole

PITTSBURGH.—In Logan district, Logan County, West Virginia, Hope Natural Gas Co. 9715 Boone County Coal Corp., elevation 1,177 ft., wildcat test was dry. Corniferous lime 5,362 ft., Oriskany sand 5,400-5,428 ft., TD 5,431 ft. Triadelphia district, United Producing Co., Inc. 11-1922 Buffalo Creek Coal & Coke Co., resulted in 4,206,000 cu. ft. gas, Berea sand, TD 3,674 ft. Harvey district, Mingo County, United Fuel Gas Co. 6977 Fee gaged 13,343,000 cu. ft. of gas in the Big lime, TD 1,880 ft. This well was not shot. Harper district, Roane County, L. D. Reed, 1 E. C. McMurray tested 2,000,000 cu. ft. gas in the Salt sand, TD 1,796 ft.

Maryland.—Garrett County, Maryland: Columbian Carbon Co. 1-1510 D. Milton Riley, after acidizing, resulted in 762,000 cu. ft. of gas, Onondaga 3,603 ft., chert 3,619 ft., gas 3,639-3,635 ft., TD 3,924 ft. Eberly & Snee are running casing in 1 McCullough Heirs, at 6,970 ft., Cumberland & Allegheny Gas Co. 1 Swartzengruber is drilling at 120 ft., after a fishing job.

Pennsylvania.—In Donegal Township, Washington County, Southwest Pennsylvania: Taylorstown Natural Gas Co. 1 W. A. Mehaffey, gaged 1,000,000 cu. ft. gas, Gordon sand, TD 2,460 ft. Unity Township, Westmoreland County, Peoples Natural Gas Co., 4003 A. J. Dotterway, is drilling at 8,636 ft., and 4008 J. R. Frola, at 6,404 ft.

WEST VIRGINIA WILDCAT FAILURE

Logan County, Logan district: Hope Natural Gas Co. 9715 Boone Co. Coal Corp., dry, elevation 1,177 ft., Corniferous lime 5,362 ft., Oriskany sand 5,400-28 ft., TD 5,431 ft.

MARYLAND SUCCESSFUL WILDCAT

Garrett County: Columbian Carbon Co. 1-1510 D. Milton Riley, 762,000 cu. ft. gas, Onondaga 3,603 ft., chert 3,619 ft., gas, 3,619-35 ft., TD 3,924 ft.

OHIO

Ray Penick et al. have extended Greer pool over into Knox Township, Holmes County, ½ mile to the east with a producer on 2 Clyde Stitzline, Section 25. Clinton sand at 2,915-38 ft. and 2,952-61 ft. had a good showing of oil natural that increased to 70 bbl. in 24 hours after a 120-qt. shot with 265,000 cu. ft. gas.

In Mt. Zion pool, Mid East 3 Gladys Griffith, Section 17, with Clinton at 2,866-2,923 ft. made 225 bbl. in 24 hours after a 150-qt. shot.

Willard Shrider 1 A. J. McConnell, Section 6, Jefferson Township, Coshocton County, a wildcat, found two small oil showings in the Clinton, logged at 3,396-3,443 ft. The test was shot with 110 qt. and made 5½ bbl. in 24 hours, but was plugged and abandoned.

OHIO WILDCAT FAILURE

Coshocton County, Jefferson Township: W. E. Shrider et al. 1 A. J. McConnell, Sec. 6, Clinton 3,396-3,443 ft., TD 3,466 ft.

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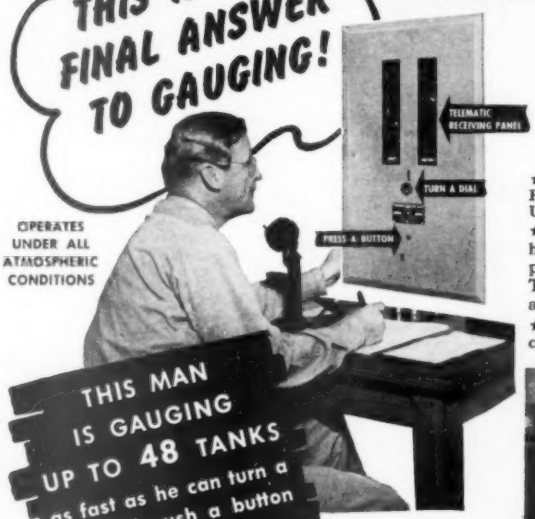

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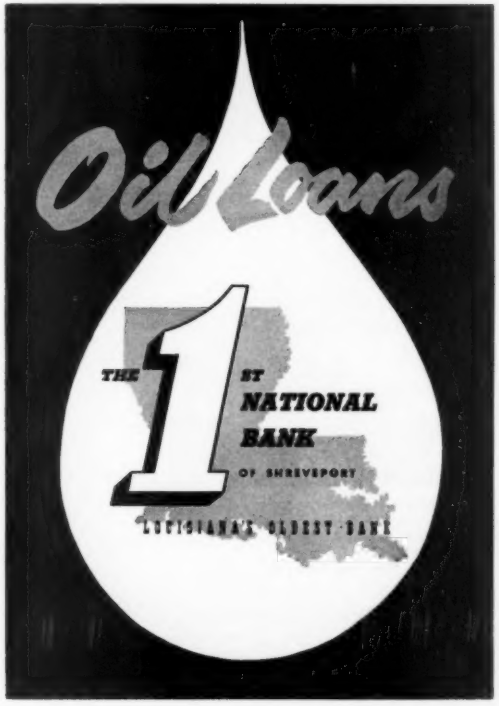

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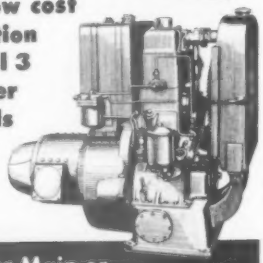

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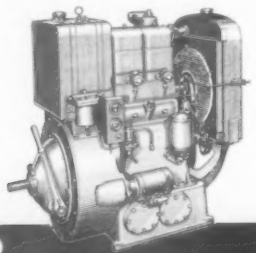

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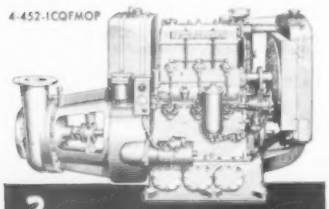

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Rocky Mountain

Dawson Discovery Appears To Be Williston's Best

DENVER.—The latest discovery in the Montana portion of the Williston basin will apparently be one of the best, following reported initial tests on the wildcat. The well is Shell Oil Co. 21-33-B-NP, C NE NW 33-22n-48e, Dawson County, 14 miles southwest of Richey pool, where Shell made the first Williston basin discovery in Montana. Early reports from the wildcat indicate the well flowed oil at the rate of 1,675 bbl. of 49°-gravity oil per day from the zone 9,185-9,260 ft. The test followed a 3,000-gal. acid treatment of the lime zone. Casing was cemented at 9,185 ft. in the wildcat and prior to the present test the zone 9,090-9,145 ft. was perforated, with no reported results of the upper test. Although Shell has not released official information as to formations and current testing, the production is now reported from the Devonian formation, which is of added importance as the Richey producers are completed in the Madison and discoveries in the general Glendive-Cedar Creek area to the southeast were made in the Siluro-Ordovician. With successful completion of the present well there will be seven widely scattered pools in a north-south trend along the west side of the Williston basin in Montana. Also of interest in this discovery is the gravity, higher than that found in any of the other Montana Williston basin wells. The majority of gravities have ranged between 32° and 38°, lending further substantiation to the new producing formation theory. Testing is continuing at the wildcat, with no new announcements of wells in the area. There are presently two dry holes between the new discovery and Richey field.

Two new Denver-Julesburg basin wells have made oil on tests. South Texas Development Co. of Houston's wildcat at 1 Derks, NW NW SE 17-8n-56w, wildcat in eastern Weld County, Colorado, flowed oil in 70 minutes and on 90-minute test the estimated rate was 7 bbl. of oil per hour. Producing zone is the J sand topped at 5,916 ft. and the test was of the zone 5,917-30 ft. Recovery was 270 ft. of oil and 300 ft. of gas and oil-cut muddy water. This wildcat is south of the Pawnee Creek area where production is gas from the D sand, and 12 miles west of Yenter pool where oil is produced from the J sand. South Texas is coring below 5,930 ft. at the well. In the Nebraska portion of the basin, The Chicago Corp.-Republic Natural Gas Co. found oil in the D sand at 1 Sell, NE NE SW 18-15n-48w, Cheyenne County. On test 4,475-82 ft. with tool open 1 hour, the well made 210 ft. of clean oil with 90 ft. of oil and gas-cut mud, 90 ft. of oil and gas-cut salt water and 260 ft. of gas-cut salt water. Top of the D sand was found at 4,442 ft. This wildcat is southeast of Gurley pool and north of Johnson pool, both of which produce oil from the D sand. The wildcat is on lands farmed out by Ohio Oil Co., Chicago Corp.-Republic Natural Gas are now drilling a series of wildcats on a large spread of leases through eastern Cheyenne County acquired from Ohio. The company's recently completed a new gas discovery southeast of the town of Sidney, as a part of this exploratory program.

Stanolind Oil & Gas Co.'s Mesaverde discovery in the Middle Mountain area of southwestern Wyoming flowed 39 bbl. of oil in 6 hours through 24/64-in. choke, for an estimated flow of 150 bbl. of oil daily. The well is 1 Unit, SW NE NE 10-12n-103w, Sweetwater County, and is of importance as one of the few Mesaverde producers in the state. The well is being completed producing from the zone 6,534-44 ft. and in addition to the oil production the well made gas at the rate of 2,280,000 cu. ft. daily. As a result of this discovery there was an extensive lease play throughout the Green River basin, with added interest in possible production from the Mesaverde zone.

Carter Oil Co.'s three important wildcats in the Uinta basin are still at testing stages, with no completion results. Each of the wells have had important oil shows, and may result in a commercial discovery from the basal Green River zone. Well 1 Joseph Smith, C SE SE 16-3s-5w (USM), in the Flat Mesa area, blew out recently flowing approximately 100 bbl. of heavily oil and gas-cut mud from the basal Green River between 9,029-32 ft. At 1 Elmer Moon, C SW SE 8-4s-3w (USM), Antelope area, Duchesne County, the operator is installing pump after the well made 71 bbl. of oil and 3 bbl. of mud in 21 hours on swab. Producing zone in the well is 6,529-54 ft. with the well plugged back from 8,246 ft., total depth. At Walker Hollow, northeast of Red Wash field, Uintah County, the company's 1 Johnson, SW SW 8-7s-24e (SLM) has been plugged back to 5,667 ft. and the operator is reported testing after the well made 2,500 ft. of 33.4°-gravity oil on 2-hour drill-stem test 5,604-57 ft.

WYOMING WILDCAT FAILURES

Carbon County: Wind River-Richard King, Jr. and Calstar Petroleum Co. 1 UPRR, C NE NW 13-18n-85w, dry, TD 5,097 ft.

Fremont County: Far West Oil Co. 1 Government-Sande, C NW SE 5-32n-93w, dry, TD 3,627 ft.

Wind River Oil Co. 1 Government, SW NE NE 15-33n-99w, dry, TD 4,302 ft.

Johnson County: Ray Hose et al 3 Government, SW NE SW 31-41n-79w, dry, TD 1,263 ft.

Natrona County: Continental Oil Co. 1 Unit, NW NE NE 10-34n-78w, dry, TD 7,368 ft.

Carter Oil Co. 1 Government, SE SE SE 27-36n-79w, dry, TD 9,034 ft.

The Chicago Corp. and Republic Natural Gas Co. 1 Government, NE SW SW 27-36n-83w, dry, TD 6,294 ft.

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COLORADO SUCCESSFUL WILDCAT

Garfield County: Greenbrier Oil Co. 1 Deacon-Brown, SE SE NE 35-5s-102w, flowed est. 2,000 M.c.f. of gas per day from Morrison 6,060 ft., new pay, TD 6,815 ft.

COLORADO WILDCAT FAILURES

Delta County: James M. Cline Oil Co. 1, SW NE SW 25-14s-94w, dry, TD 730 ft.

Logan County: Bay Petroleum Co. 1 Meisner, NW NE SW 5-8n-52w, dry, TD 4,826 ft.

Moffat County: Crusader Corp. 1 Sharp Government, NW SW SE 2-3n-101w, dry, TD 3,698 ft.

Crusader Corp. and Frontier Refining Co. 1 Government, C SE NE 2-5n-98w, temporarily suspended, TD 1,696 ft.

Morgan County: Roden, Darden & McRaie 1 Peterson, NE SE SE 9-1n-55w, dry, TD 5,500 ft.

Bay Petroleum Co. 1 Anderson, SE SE NW 15-6n-55w, dry, TD 5,448 ft.

Rio Blanco County: General Petroleum Corp. 46-27 Government, SE NE SW 27-1n-98w, dry, TD 3,223 ft.

Union Oil Co. 1 Colorow Government, C SW SW 16-2n-97w, dry, TD 3,348 ft.

WESTERN NEBRASKA WILDCAT FAILURES

Banner County: Northern Drilling & Production Co. 1 Barrett, NE NE NE 5-19n-55w, dry, TD 5,641 ft.

Chase County: Suhr-Fiedler & Lock 1 "A" Lock, NE NW SW 7-6n-41w, dry, TD 3,030 ft.

Kimball County: Magnolia Petroleum Co. 1 Mockett, NE NE 11-12n-47w, dry, TD 7,159 ft.

Lincoln County: Oil Hunters, Inc. 1 Steck, SW NE NE 8-12n-34w, dry, TD 4,736 ft.

Red Willow County: J. E. Palensky & Son 1 Gehring, SE SE NE 25-4n-28w, dry, TD 3,510 ft.

UTAH WILDCAT FAILURES

Emery County: Paul B. English and Byrd-Frost 2 Rath, SE SE SW 18-26s-7e, dry, TD 1,001 ft.

Uintah County: Continental Oil Co. 4 Oil Springs, SW NW SW 18-12s-25e (SLM), dry, TD 3,498 ft.

NORTHERN NEW MEXICO SUCCESSFUL WILDCAT

San Juan County: Blackwood & Nichols 1 NE Blanco unit, NW SE NE 27-31n-7w, IP 536 M.c.f. of gas daily from Dakota 7,792 ft., TD 8,108 ft.

MONTANA WILDCAT FAILURES

Dawson County: The Texas Co. 1 NPG-NCT 7, C SE SE 19-14n-55e, dry, TD 10,805 ft.

Stillwater County: The Texas Co. 1 Eggen, SW SE 33-5s-17e, shut down, TD 5,377 ft.

Toole County: Two Hugh's Oil & Gas Co. 1 Pederson, SE SE SE 30-36n-1e, dry, TD 1,850 ft.

NORTH DAKOTA SUCCESSFUL WILDCAT

Williams County: Amerada Petroleum Corp. 1 North Dakota "E," C NW NW 16-154n-95w, pumped 50 bbl. of oil and 33 bbl. water per day from Madison 8,482 ft., new field, TD 8,928 ft., PBTD 8,722 ft.

SOUTH DAKOTA WILDCAT FAILURE

Bennett County: H. O. English 1 Kocer, C SW 30-37n-36w, dry, TD 3,370 ft.

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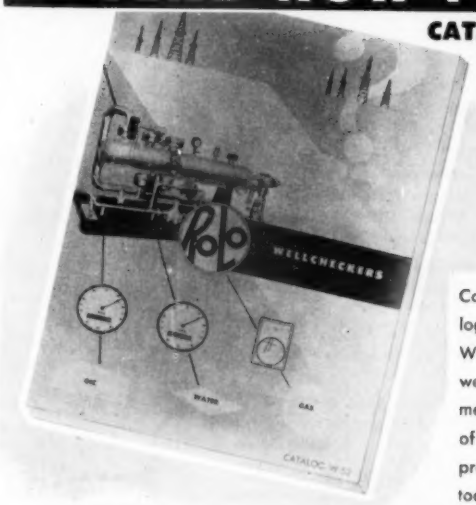

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Kansas

New Mississippian Pool For East Kingman County

ANOTHER Mississippian reservoir is being opened in extreme eastern Kingman County, near the Sedwick County line where Pabco Drilling Co. is testing its 1 Casley, SW SW NW 11-28-5. The well flowed 72 bbl. of oil in the first 6 hours following acidization from open hole at 3,797-3,801 ft. No water was indicated. Top of the Mississippian was logged at 3,754 ft. Location is southwest of the Bartholomew area on the county line.

Ed Adair and Lee Phillips are putting their 1 Shumway, wildcat north of the Sittner pool, in northern Stafford County, on the pump following swabbing tests of Arbuckle lime at 3,566-70 ft. The well swabbed initially at the rate of 10 bbl. per hour. Following acidization, it made 120 bbl. during the first hour. Spot location is in the SW SW NW 11-28-5.

Promising showings also have been encountered in another Stafford County wildcat, Westgate-Greenland Oil Co. 1 Batchman, SW NE NE 9-23s-14w, 6 miles northwest of St. John, in the western part of the county. Showings were in the Lansing-Kansas City section, through which casing has been run to 3,712 ft. Total depth is 4,058 ft. in Arbuckle lime, which failed to show. Top of the Lansing was logged at 3,544 ft. A 60-minute drill-stem test at 3,656-76 ft. got 1,980 ft. of gas, 60 ft. of oil-cut mud (30 ft. heavily cut), and 30 ft. of frothy oil. A test lower in the pay at 3,690-3,718 ft. got 425 ft. of gas-cut muddy oil and water.

Saturn Drilling Co. has a new Lansing discovery in southeastern Reno County, where its 1 Nicklaus, SEc Lot 3, 3-26-4, swabbed 12 bbl. of net oil per hour in a 6-hour test, and now is being put on the pump. Pay is open through casing perforations at 3,249-51 ft. with top of the Lansing at 2,841 ft. The well did not show in the Arbuckle, topped at 4,213 ft. and drilled to 4,243 ft. Location is east of production in the Hilger pool.

KANSAS SUCCESSFUL WILDCAT

Decatur County: E. K. Carey 1 Managhan, SW SW SW 15-2s-27w, pumped 24 bbl. of oil from Lansing-Kansas City 3,514-3,606 ft., TD 4,015 ft. (opens Managhan pool).

KANSAS WILDCAT FAILURES

Cowley County: C. L. Carlock 1 Logan, SE NE NE 7-32s-4e, dry, TD 2,012 ft.

K. T. Wiedemann 1 Ryding, NW NW NW 3-30s-7e, dry, TD 2,955 ft.

Spencer & Tobias 1 Gotlob, NE NE SW 2-34s-3e, dry, TD 3,404 ft.

Decatur County: H. Gore 1 Boland, NE NE NE 15-5s-27w, dry, TD 3,884 ft.

Ellis County: Imperial Petroleum 1 Kroeger, NE NE NE 31-13s-20w, dry, TD 3,988 ft.

Graham County: H. Gore 1 DeSaire, NW NW SE 33-8s-22w, dry, TD 3,941 ft.

Jones, Shelburne & Farmer 1 Drassfield, NE NE SE 2-10s-22w, dry, TD 3,950 ft.

Hodgeman County: GMR et al 1 Hartley, NE NE NE 2-22s-25w, dry, TD 4,641 ft.

Marion County: Aladdin 1 Stenzel, SW SE NW 18-19s-5e, dry, TD 2,532 ft.

Meade County: Deep Rock Oil Corp. 1 Adams "B," C NW NE 16-35s-29w, dry, TD 6,296 ft.

McPherson County: Anschutz-Sam Pack 1-A Mitchell, SW SW SE 27-20s-4w, dry, TD 3,885 ft.

Pawnee County: M. B. Armer 1-A English, CSL SW NE 1-21s-15w, dry, TD 3,765 ft.

Rush County: D. R. Lauck 1 West, SE SE NE 6-19s-19w, dry, D 4,180 ft.

Sumner County: W. L. Hartman 1 Hamilton, NW NW SE 6-31s-4w, dry, TD 4,742 ft.

Wallace County: Rexall et al 1 Hill, C SW SE 36-11s-42w, dry, TD 5,215 ft.

Central Area

ILLINOIS

Ashland Oil & Refining Co. is putting its new Waltersburg discovery well northeast of Maunie, in White County, on the pump for completion following swabbing tests in which the well produced at an average rate of 12 bbl. of oil per hour. The well, 1 Bingham heirs, SW NW SE 19-5s-14w, is ¾ mile from two small lime producers and 1½ miles from other production in the Maunie field, 9 miles east of Carmi. Pay is at 2,302-13 ft. A west offset is drilling.

Illinois Mid-Continent Co. is opening two new pay zones for the Goldengate area at its 1 Locke, NW NW SE 17-2s-9e, 2 miles southwest of the town of Goldengate. Testing McClosky lime, opposite which casing is perforated at 3,367-71 ft., the well swabbed 1 bbl. of oil per hour natural. Following acidization, it "kicked off" and started to flow. Production also has been indicated in O'Hara lime, the other new pay zone, which will be opened later. A drill-stem in this zone while hole was being drilled yielded 2,140 ft. of oil and 120 ft. of oil-cut mud.

INDIANA

Stanley T. Welch and associates are opening another new pool in southern Vanderburgh County, 7 miles south of Evansville, at their 1 Kuester, SE SE SE 35-7s-11w, which swabbed 72 bbl. of net oil with 24 bbl. of water per day from McClosky lime at 2,476-85 ft. The well is being put on the pump for completion. The discovery is the third this year in the immediate area, located just across the Ohio River from Henderson, in Henderson County, Kentucky.

Affeld Oil Co. 1 Starrett, NE NE SE 20-2n-8w, ¾ mile northeast of production of the Monroe City pool, 2 miles southeast of Monroe City, filled 800 ft. of clean oil and 290 ft. of mud-cut oil in a 60-minute drill-stem test of Rosiclare lime at 1,397-1,401 ft. No water was indicated. Casing has been run for completion.

EASTERN KENTUCKY

In the Martin County sector of Big Sandy gas field, United Fuel Gas Co. have a dually

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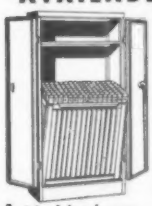

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completed gas well at their 71 Federal Gas, Oil & Coal Co. Production was obtained from the Big lime and the Devonian black shale with a combined open flow of 573,000 cu. ft. of gas daily at a total depth of 3,464 ft.

In western Elliott County 1-S-75 Raymond Long et al are running casing at a total depth of 1,185 ft. to shut off water found in the Corniferous lime at 1,175 ft. with top reported at 1,165 ft. Operators are running casing prior to deepening to possible pays.

MICHIGAN

Last reported pump testing at the Lud Segerlund 1 Caner et al, NE NE NE 11-19n-5w, Greenwood Township wildcat, Clare County, showed this Dundee well to be pumping and flowing at the rate of 8 bbl. of fluid an hour, ⅓ of which was water. The water showing at this wildcat discovery appears to have been on a steady increase since well was acidized with 1,000 gal. at its total depth, 4,064 ft., exactly 12 ft. in the Dundee horizon. This increasing amount of water, plus the general performance of the well since it was acidized has been causing increased alarm in industry circles. However, rotary rig had been moved this week to the south 40-acre offset, Segerlund's 1 Kuehl, NE SE NE, 11-19n-5w, and location had been staked for the direct north 40-acre offset, in the NE SE SE 2-19n-5w.

ILLINOIS WILDCAT FAILURES

Clark County: W. Mathis 1 Hopkins, SW NW SW 28-9n-14w, dry, TD 693 ft.

Fayette County: Homer Luttrell 1 Magnus, NW NE SE 27-5n-3e, dry, TD 2,024 ft.

Jasper County: Walker Oil Co. 1 Gunn, NE SW SE 22-7n-14w, dry, TD 1,000 ft.

W. L. Griffith 1 Hartrich, SE NE SE 31-6n-14w, dry, TD 2,867 ft.

Lawrence County: N. Appleby 1 Cooley, NW NE NW 8-3n-11w, dry, TD 1,879 ft.

Marion County: Homer Luttrell 1 Robb et al, SW NW SE 18-4n-3e, dry, TD 2,275 ft.

Montgomery County: L. Marsch 2 Doyle, NW SE SE 21-10n-4w, dry, TD 603 ft.

Moultrie County: E. A. Obering 1 McReynolds, NE NE SW 18-14n-4e, dry, TD 3,494 ft.

Shelby County: Earl Landon 1 Stewart, SE SW SW 35-14n-2e, dry, TD 1,325 ft.

Wabash County: J. S. Young, Jr. 1 Fox, NE NW NE 20-1n-11w, dry, TD 2,214 ft.

INDIANA SUCCESSFUL WILDCAT

Posey County: Carter Oil Co. 1 Rowe heirs, SE NE NE NW 24-7s-14w, IP 40 bbl. lower Renault 2,854-60 ft., TD 3,151 ft. (extends Mount Vernon pool).

INDIANA WILDCAT FAILURES

Daviess County: F. L. Burkhart 1 Callahan, SE SE NW 5-5n-5w, dry, TD 580 ft.

Dubois County: George & Wrather 1 Jasper, SW SW SW 17-1s-4w, dry, TD 488 ft.

Gibson County: George & Wrather 1 Holzmeyer, NW NW SW 18-3s-9w, dry, TD 2,077 ft.

Posey County: T. & H. Corp. 1 Smith, SW SW NE 6-2s-11w, dry, TD 4,300 ft. (geological wildcat Owensville North pool).

Jet Oil Co. 1 Pipkin, SE SW NW 35-6s-12w, dry, TD 2,746 ft.

Bayer Petroleum Co. et al 1 Hastings, NW NE NE 10-8s-14w, dry, TD 3,077 ft.

Spencer County: W. A. Schuller 1 Richardson, SE NW NW 20-6s-4w, dry, TD 875 ft.

Tippecanoe County: J. L. Hassett 1 Summers, NE NE NW 13-21n-4w, dry, TD 1,320 ft.

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Vanderburgh County: Indiana Farm Bureau, 1 Lutz, NW NE SW 19-4s-11w, dry, TD 2,695 ft.

WESTERN KENTUCKY SUCCESSFUL WILDCATS

Hopkins County: The Texas Co. 1 Eastwood, N½ NE SW NE 8-L-25, IP 7 bbl., Paint Creek 2,110-15 ft., TD 3,524 ft. (discovery well Old Salem pool).

George Hoffman and Basin Drilling Co. et al 1 Hobgood-Lafitte, NE NW NE NW 13-L-26, IP 32 bbl., Aux Vases 2,666-72 ft., TD 2,775 ft. (discovery well Pond River East pool).

WESTERN KENTUCKY WILDCAT FAILURES

Daviess County: C. C. Ryer et al 1 Foster, SW SW SE SE 22-Q-28, dry, TD 1,802 ft.

Felmont Oil Co. 1 Ballard, NW SE NW 17-O-26, dry, TD 2,427 ft.

Henderson County: Iglehart Drilling Co. 1 Kuester-Gentry, S½ NE NE NW 19-

(Continued on page 484)

California

Fault-Block Discovery Completed in Cuyama Valley

LOS ANGELES.—Richfield Oil Corp. has made an oil discovery in the Cuyama Valley about ½-mile east of the southern tip of Russell Ranch field in Santa Barbara County. The new producer, designated Russell A 15-9, is located near the west line of Section 9-10n-27w. It was completed for 1,670 bbl. a day of 39.5°-gravity oil and 640,000 cu. ft. of gas through a 48/64-in. choke from Miocene interval 3,600-3,674 ft. Since Richfield had previously drilled a dry hole between Russell Ranch field and the new producer, it is assumed that the discovery is an accumulation against a fault.

This is the first discovery in the Cuyama Valley since Cuyama Central field was brought in by Seaboard Oil Co. in May, 1951. To date, this is a one-well field with the discovery well a small pumper.

Richfield has been searching for oil in the area where it made its discovery for many months and drilled four dry holes before hitting the pay.

Only three wildcats are presently drilling in the Cuyama Valley. A fourth will get under way shortly in the southeastern end of the Valley when Texas Co. spuds the Signal-Maxwell 1 in Section 19-9n-25w. This test will be watched with considerable interest because there has been relatively little prospecting in the area, although several companies have large holdings there. Superior Oil Co. recently drilled an unsuccessful deep test about 1 mile west of the Texaco location.

In Kern County, interest is centered on Standard of California's 7D wildcat in Section 7-32s-24e, Buena Vista area. Standard ran two tests of the lower Etchegoin above the fractured shale section in this well last week, recovered 50 ft. of clean oil and has run casing.

In the west Edison area of the county, Patrick A. Doheny has staked location for a second test one location west and a little north of a small pumper, the DiGiorgio 1, in Section 3-31s-29e, which pumped about 20 bbl. a day of 27°-gravity oil on completion, but which is now idle. Producing interval was 4,842-4,921 ft., with top of the schist located at 4,916 ft.

Richfield Oil Corp. continues to work on its KCL D 16-28 in the Wheeler Ridge area of Kern County, Section 28-11n-20w, a southeasterly offset to its Eocene discovery of a few months ago. A fishing job has tied up drilling operations, but the well is now being deepened below 11,800 ft.

CALIFORNIA WILDCAT FAILURES

Colusa County, Davis Ranch area: Humble Oil & Refining Co. 1 O. P. Davis, 30-15n-1w, dry, TD 7,500 ft., elev. 44 ft.

Kern County, Bowerbank area: E. A. Bender 1 Salisbury, 7-29s-24e, dry, TD 4,760 ft., elev. 278 ft.

Fruitvale area: W. R. Whittaker Co., Ltd. 1 Whittaker, 11-29s-27e, dry, Fairhaven 2,855 ft., TD 2,901 ft., elev. 443 ft.

McDonald Anticline area: Ferguson & Bosworth 2 Layman B, 18-28s-20e, dry, TD 2,556 ft., elev. 954 ft.

Midway Sunset area: General Petroleum Corp. 43 Globe, 15-31s-22e, dry, TD 6,054 ft., elev. 1,507 ft.

Rosedale area: Standard Oil Co. 84 KCL-30, 33-28s-26e, dry, TD 8,002 ft., elev. 364 ft.

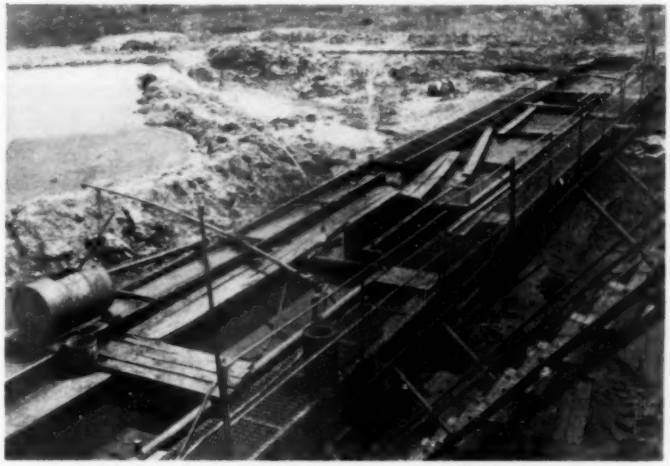
Los Angeles County, Santa Fe Springs area: Albercalif Petroleum, Ltd. 1 Accarius, 32-2s-11w, dry, Meyer 4,912 ft., TD 5,200 ft. elev. 171 ft.

Saugus area: Superior Oil Co. 48-21 N. L. & F., 21-4n-16w, dry, TD 13,553 ft.

Sutter County, Marysville area: Richfield Oil Corp. B-2 Butte Comm., 22-16n-2e, dry, TD 3,900 ft., elev. 171 ft.

Ventura County, Aliso Canyon area: Union Oil Co. X-9 Ex-Mission, 24-4n-22w, dry, TD 2,891 ft., elev. 1,434 ft.

Santa Paula area: Neaves Petroleum De-



Mud System furnished by S&R Pierce Junction Field, Houston, Texas

S & R MUD PIT

Hundreds of S&R Mud Pits are in use by operators throughout the Oil Industry. S&R Mud Pits are practically indestructible . . . with any reasonable care in loading and transporting, they will give years of service.

Standard pits are 6' deep, 30' long, 7'6" wide and have a capacity of 234 barrels. Bottoms are 1/4" steel plate; sides of 3/16" or 1/4" as specified. Heavy reinforcing . . . 3" channel iron ribs on 36" centers . . . provides utmost strength and rigidity along the sides. Top cross braces are above the mud level in the tank, so that the interior is absolutely free of obstruction. A clean-out plate is furnished at one end.

S&R Steel Mud Pits are skidded on 6" H-Beams, with heavy cross-braces along the length. Skids are 8' wide and 33' long; the pits may be hauled on any standard oil field trailer. Beams are recessed at each end, so that the winch line may be snubbed or wrapped around the ends of the braces for speed, safety and convenience in loading and unloading.

Write for further information and catalog.

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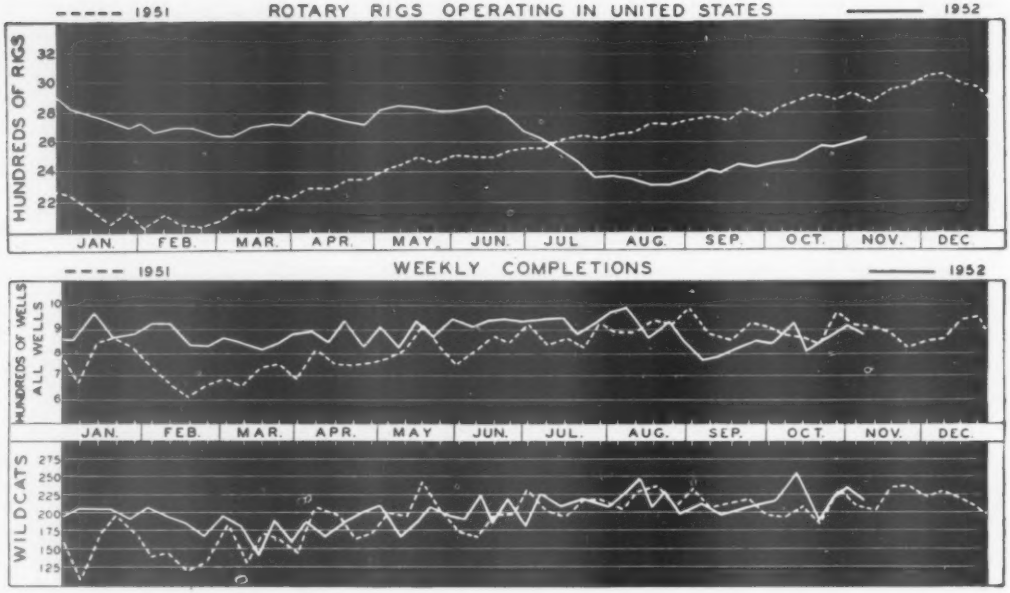


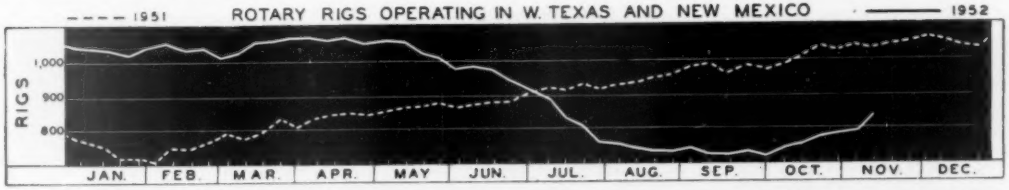
CURRENT STATISTICS

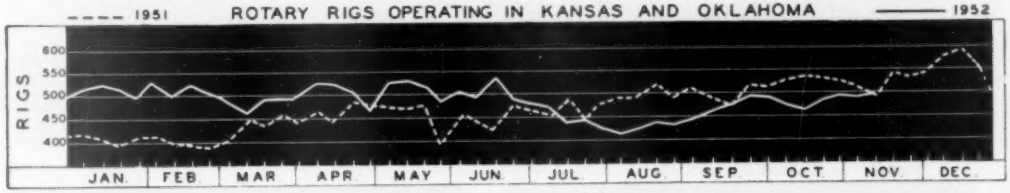
EXPLORATION

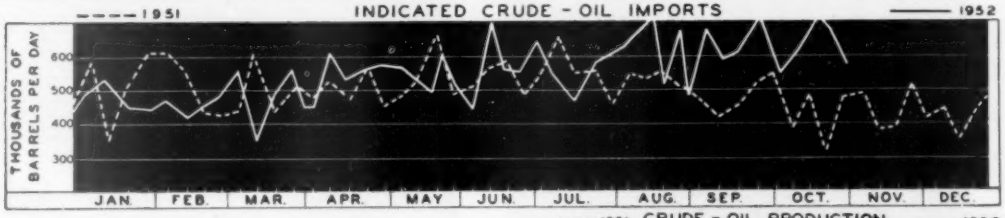
WEEKLY WELL COMPLETIONS . . . WEEK ENDED NOVEMBER 8, 1952

	Total of all wells					Nov. 8		Wildcat completions and discoveries					Cumulative total, 1952				
	Comp.	Oil	Gas	Dry	Footage	1952	1951	Oil	Dist.	Gas	Dry	Total	Oil	Dist.	Gas	Dry	Total
New York	16	8	0	*8	23,500	673	559	0	0	0	0	0	0	0	0	2	2
Pennsylvania	40	21	2	†17	67,757	1,713	1,482	0	0	0	0	0	0	0	0	2	2
West Virginia	12	0	10	2	33,237	536	530	0	0	0	1	1	0	0	4	8	12
Ohio	23	7	7	‡9	47,094	868	832	0	0	0	1	1	2	0	8	17	27
Indiana	27	5	1	21	47,075	1,085	1,190	1	0	0	9	10	31	0	2	320	353
Kentucky	36	14	3	19	76,706	1,122	1,103	2	0	0	9	11	23	0	1	233	257
Illinois	41	13	0	28	98,554	1,772	2,122	0	0	0	10	10	23	0	1	491	515
Michigan	13	3	0	10	30,768	617	644	0	0	0	3	3	23	0	5	209	237
Kansas	71	26	7	38	244,607	3,928	3,789	1	0	0	15	16	87	0	14	648	749
Nebraska	9	3	0	6	47,728	276	194	0	0	0	5	5	11	0	2	153	166
Oklahoma	138	80	7	§51	483,170	5,008	4,780	3	0	0	11	14	88	3	12	520	623
Texas	264	143	5	116	1,247,797	14,695	14,025	17	1	1	78	97	688	46	107	3,348	4,189
North Central (Dist. 7-B & 9)	103	60	0	43	366,888	4,662	4,236	11	0	0	30	41	387	2	24	1,359	1,772
West (Dist. 7-C & 8)	74	49	0	25	444,561	4,439	4,291	5	0	0	16	21	151	1	6	629	787
Panhandle (Dist. 10)	5	2	0	3	27,948	560	607	0	0	0	3	3	4	0	8	55	67
Eastern (Dist. 5 & 6)	14	6	1	7	75,698	780	1,016	0	0	0	4	4	18	5	4	203	230
Gulf Coast (Dist. 2 & 3)	31	15	1	15	173,164	2,195	1,940	1	1	0	12	14	64	27	29	487	607
Southwest (Dist. 1 & 4)	37	11	3	23	159,538	2,059	1,935	0	0	1	13	14	64	11	36	615	726
Louisiana	50	24	7	19	295,118	2,012	1,858	0	0	0	4	4	38	17	13	276	344
Northern	28	16	3	9	107,809	1,106	1,035	0	0	0	3	3	16	0	7	143	166
Southern	22	8	4	10	187,309	906	823	0	0	0	1	1	22	17	6	133	178
Arkansas	14	5	0	9	57,003	356	362	1	0	0	1	2	8	0	0	75	83
Mississippi	6	2	0	4	46,922	291	306	0	0	0	2	2	16	2	1	134	153
Southeastern States	2	1	0	1	9,367	60	46	0	0	0	1	1	3	0	1	32	36
Montana	8	3	0	5	38,770	293	185	0	0	0	3	3	7	0	1	75	83
Wyoming	21	12	1	8	100,065	598	642	0	0	0	7	7	21	0	4	116	141
Colorado-Utah	14	0	2	12	58,212	466	254	0	0	1	10	11	18	0	9	206	233
New Mexico	21	9	8	4	127,734	900	597	0	0	1	4	5	35	2	2	93	132
California	47	28	2	17	203,182	2,101	1,979	0	0	0	11	11	64	0	7	434	505
North Dakota	4	3	0	1	37,560	94	8	1	0	0	0	1	5	0	0	23	28
Miscellaneous (Md., S. D.)	2	0	1	1	7,294	62	88	0	0	1	1	2	0	0	22	27	49
Total United States	879	410	63	406	3,429,220	39,526	37,575	26	1	4	186	217	1,191	70	216	7,442	8,919
Total previous week	913	409	73	431	3,493,910			18	1	7	208	234	1,165	69	212	7,256	8,702
Total November 10, 1951	905	478	70	357	3,556,185			35	0	1	165	201	1,337	70	217	7,227	8,851

Service wells included: *8, †15, ‡2, §3.



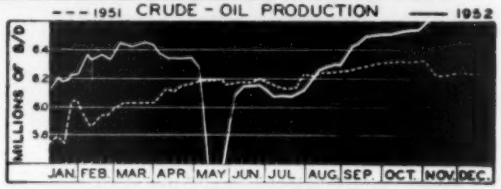


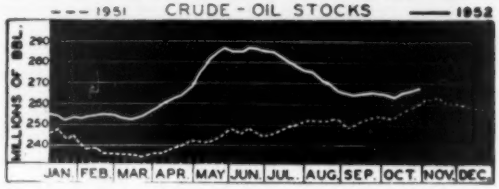


DAILY AVERAGE PRODUCTION FOR WEEK

	November 8, 1952			Nov. 1
	Crude oil	Lease condensate	Total	total
Alabama	3,200		3,200	3,100
Arkansas	75,200	600	75,800	76,050
California	987,550		987,550	980,200
Colorado	87,300		87,300	87,300
Eastern	57,800		57,800	58,000
Florida	1,525		1,525	1,525
Illinois	163,700		163,700	168,700
Indiana	33,700		33,700	33,600
Kansas	337,000		337,000	344,900
Kentucky	31,200		31,200	31,300
Louisiana	647,900	28,800	676,700	670,775
North	109,850	2,250	112,100	111,550
South	538,050	26,550	564,600	559,225
Michigan	38,000		38,000	36,400
Mississippi	91,150	3,750	94,900	95,450
Montana	28,000		28,000	27,500
Nebraska	8,800		8,800	8,700
New Mexico	172,775	450	173,225	172,650
Oklahoma	535,300		535,300	534,600
Texas	3,050,175	44,800	3,094,975	3,002,450
Dist. 1	39,100	250	39,350	37,300
Dist. 2	175,275	4,600	179,875	173,700
Dist. 3	494,975	24,200	519,175	508,500
Dist. 4	276,000	5,300	281,300	277,275
Dist. 5	54,150	250	54,400	51,775
Dist. 6	134,275	4,000	138,275	131,450
East Texas field	256,700		256,700	249,000
Dist. 7-B	118,625	100	118,725	110,925
Dist. 7-C	179,000	5,500	184,500	178,150
Dist. 8	1,049,775	275	1,050,050	1,015,250
Dist. 9	191,650	300	191,950	186,775
Dist. 10	80,650	25	80,675	82,350
Utah	5,700		5,700	5,600
Wyoming	196,000		196,000	196,000
North Dakota	10,000		10,000	6,500
Total U. S.	6,561,975	78,400	6,640,375	6,541,300
Change from previous week, up			99,075	
Canada	146,975		146,975	210,675
Total U. S. production January 1-November 8			1,938,956,450 bbl.	
Same period last year (crude plus cond.)			*1,921,736,350 bbl.	

*Including 25,466,450 bbl. condensate.



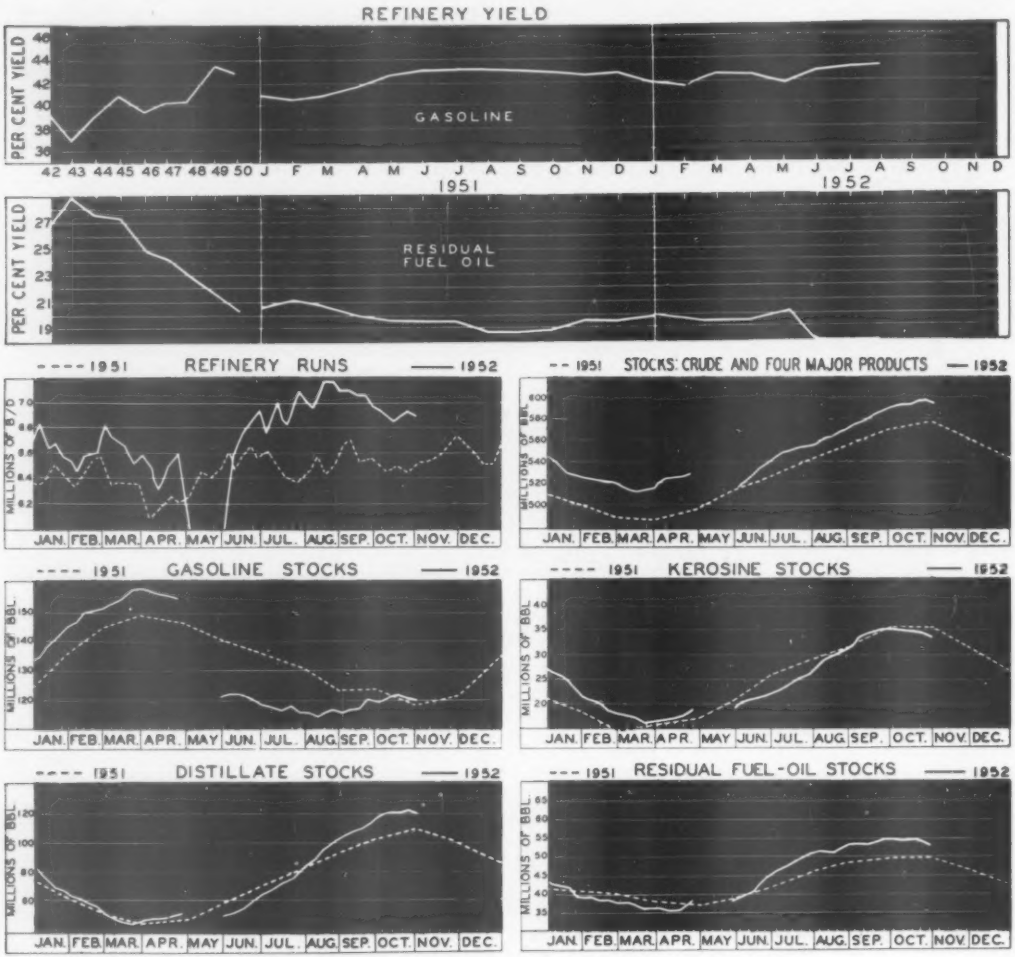


CRUDE-OIL STOCKS BY STATES OF ORIGIN*

(Thousands of barrels)

	Nov. 1, '52	Oct. 25, '52	Nov. 3, '51
Pennsylvania Grade	2,198	2,219	1,944
Other Appalachian	1,984	2,289	1,668
Illinois, Indiana, Michigan	12,220	12,306	13,064
Arkansas	2,918	2,885	2,705
Louisiana	16,162	15,960	15,124
North	2,567	2,497	2,845
Gulf	13,595	13,463	12,279
Mississippi	2,993	3,054	3,460
New Mexico	7,578	7,748	7,334
Oklahoma and Kansas	37,866	38,233	39,294
Texas	129,891	128,175	126,161
East Texas proper	12,393	12,079	(†)
West Texas	59,040	58,660	(†)
Texas Gulf	26,186	25,683	(†)
Other Texas	32,272	31,753	(†)
Rocky Mountain	15,120	14,707	15,168
California	31,594	31,526	29,629
Foreign	8,011	8,373	6,610
Total	268,535	267,475	262,161

*Bureau of Mines. †Not comparable with current week.

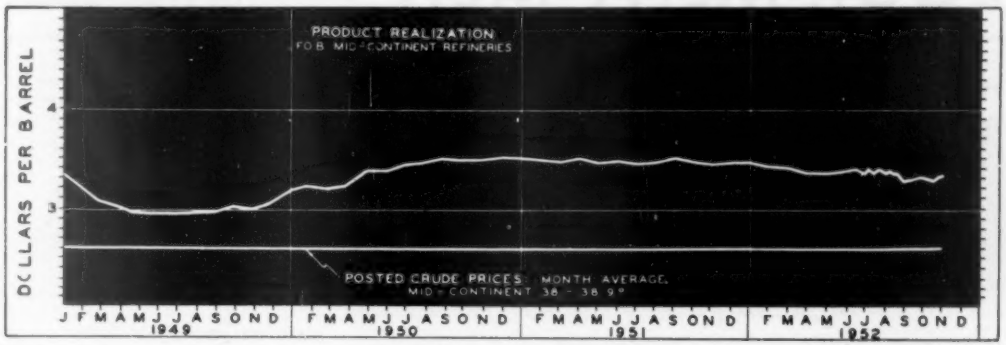

REFINERY YIELD
PER CENT YIELD
GASOLINE
42 43 44 45 46 47 48 49 50 J F M A M J J A S O N D J F M A M J J A S O N D
1951
1952
PER CENT YIELD
RESIDUAL FUEL OIL
---- 1951 REFINERY RUNS —— 1952
MILLIONS OF B/D
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
-- 1951 STOCKS: CRUDE AND FOUR MAJOR PRODUCTS — 1952
MILLIONS OF BBL.
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
---- 1951 GASOLINE STOCKS —— 1952
MILLIONS OF BBL.
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
---- 1951 KEROSINE STOCKS —— 1952
MILLIONS OF BBL.
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
---- 1951 DISTILLATE STOCKS —— 1952
MILLIONS OF BBL.
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.
--- 1951 RESIDUAL FUEL-OIL STOCKS —— 1952
MILLIONS OF BBL.
JAN. FEB. MAR. APR. MAY JUN. JUL. AUG. SEP. OCT. NOV. DEC.

A.P.I. REFINERY REPORT, NOVEMBER 8

(Thousands of barrels)

District—	Daily avg. runs	Daily average production— Gaso.*	Kero.	Dist.	Resid.	Stocks‡— Gaso.†	Kero.	Dist.	Resid.	Bureau of Mines, November 1951— Daily avg. runs	Daily average production— Gaso.*	Kero.	Dist.	Resid.
East Coast	1,072	408.9	36.2	272.7	250.0	29,897	14,849	43,183	12,286	1,022	402.5	46.9	279.8	232.3
Appalachian:														
District 1	93	33.4	5.1	12.7	11.1	3,838	568	1,739	743	103	44.1	5.6	16.4	14.1
District 2	90	37.3	9.0	13.4	14.6	1,591	325	655	372	78	34.1	7.0	9.6	17.8
Ind., Ill., Ky.	1,255	706.7	80.9	240.4	151.7	25,039	7,281	22,506	6,300	1,249	671.9	76.9	219.9	186.0
Okla., Kans., Mo.	572	328.3	9.1	146.3	56.7	11,494	2,046	13,629	1,676	508	285.1	17.5	116.7	65.1
Inland Texas	270	197.7	11.0	47.9	43.7	4,580	509	2,522	1,219	242	164.6	12.0	39.2	39.3
Texas Gulf Coast	1,702	791.8	148.6	427.6	245.0	17,976	3,773	15,065	8,075	1,570	727.6	139.0	347.0	252.3
La. Gulf Coast	513	258.3	70.4	105.4	44.9	6,336	2,589	4,903	1,890	530	232.8	74.3	109.8	59.9
N. La. and Ark.	83	32.9	7.6	20.0	5.4	2,664	683	993	288	80	34.0	7.7	16.9	7.3
Rocky Mountain:														
New Mexico	18	11.1		2.9	3.9	130		67	109	17	10.2	.5	2.2	3.7
Other Rocky Mtn.	213	103.0	5.0	39.3	38.0	3,099	405	2,134	963	219	105.9	8.8	41.0	47.7
California	979	442.7	4.7	153.7	346.1	14,730	355	12,750	19,681	991	417.0	6.6	159.0	378.2
Nov. 8, 1952	6,860	3,352.1	387.6	1,482.3	1,211.1	121,374	33,383	120,146	53,602	6,609	3,129.8	402.8	1,357.5	1,303.7
Nov. 1, 1952	6,892	3,383.9	369.6	1,415.3	1,217.9	120,563	33,760	120,267	53,292					
Nov. 10, 1951	6,573	3,069.9	410.4	1,340.0	1,296.6	119,559	35,260	109,743	49,244					

*At refineries including natural blended. †Finished and unfinished. ‡At refineries, bulk terminals, in transit, and in pipe lines.



In this trend chart refinery realization is based on average Mid-Continent grade crude oil (not 38° gravity only) and average prices for refinery products as published in The Oil and Gas Journal basis Oklahoma (Group 3). Refinery yields confined to gasoline, kerosine, distillate and fuel oil. Realization averaged $3.35 for week ended November 1, $3.33 for previous week, and $3.48 for November 1951. The above trend information is based on volumes and current prices and therefore does not reflect changes in operating costs.

REPRESENTATIVE QUOTATIONS

Representative spot-market quotations of leading suppliers as of November 12, 1952. Figures are f.o.b. plant for tank-car shipments in cents per gallon, except for residual fuel oil which shows the price per barrel and wax, in cents per pound.

GASOLINE, KEROSINE, AND FUEL OILS

	Mid-Continent Group 3	New York Harbor (barge)	Texas Gulf Coast
Regular gasoline, 80-82 octane	10⅜-10½	12.125-12.75	10¾-11
Premium gasoline, 86-88 octane	11⅜-11½	13.25-14.0	11¾-12
42-44 w.w. kerosine	8⅝-9	10.45-10.65	9
No. 2 straw fuel oil	7⅝-8	9.45-9.65	8-8.25
No. 6 residual	$0.85-1.00	$2.00-2.25	$1.50-1.75

NATURAL GASOLINE

	Group 3	North Texas	N. La.
Grade 26-70	6⅞	6¾	6⅝
Grade 18-55	8.25	7.75	8.0

LUBRICATING OILS
South Texas

200 vis., No. 2-3 neutral	13-13.5
750 vis., No. 3-4 neutral	16
2,000 No. 5-6 neutral	18-19

LUBRICATING OILS
Mid-Continent

150-160 vis., D bright stock, 0-10 pp.	25-27
200 vis., No. 3 neutral, 0-10 pp.	13-15

Western Pennsylvania

145-155 vis., 10 p.t. bright stock	32.5
180 vis., 0 p.t. neutral	31.5

WAX
Mid-Continent

132-134 A.M.P.	5.5

REPORTS from northern and northeastern states indicate that the colder weather is giving a little strength to the light-fuel market.

For the country as a whole, this additional demand resulted in the season's first reduction in distillate stocks during the week ended November 1. Decreases were reported for all districts except California. Combined reductions for Districts 1 and 3 totaled 900,000 bbl. Stocks in District 2 were down 336,000 bbl.

Total distillate stocks on November 1 were 8.9 per cent greater than at the same time last year. Combined stocks in Districts 1 and 2 were 6.9 per cent larger than last year. A gain of 5.3 per cent was reported for District 2. Distillate stocks in California were up 3,410,000 bbl. or about 36 per cent.

New York Harbor prices for No. 2 fuel are a little firmer than a week ago. Some material still is available in barge lots at a low of 9.45 cents a gallon, compared with a low the preceding week of 9.4 cents and the ceiling price of 9.65 cents.

Heavy-fuel markets continued soft in all areas east of California. Very little open-market activity has been reported in New York Harbor for the past several days, but some barge-lot material is still available at $2.00 compared with normal quotations of $2.10 for No. 6 with no sulfur guarantee. Gulf Coast prices on residual are holding at $1.50, indicating the lower prices in New York are due to low tanker rates for dirty vessels.

Very little residual is moving out of the Mid-Continent area except for normal shipments against contracts. Electric-utility plants are using more fuel since most rivers are too low for full power generation at hydroelectric plants. Many of the steam plants now are using gas but will have to change to residual fuel or coal if cold weather increases domestic and commercial demand for natural gas. In some areas, coal cannot compete with heavy fuel.

CRUDE PRICES

GRAVITY SCHEDULE

	Signal Hill, Calif.‡	Oklahoma, Kansas	Gulf Coast Tex.*	West Tex.†
18-18.9	$1.93	....	....	....
19-19.9	1.98	....	....	....
20-20.9	2.03	$2.25	....	$2.12
21-21.9	2.07	2.27	....	2.14
22-22.9	2.12	2.29	....	2.16
23-23.9	2.18	2.31	....	2.18
24-24.9	2.24	2.33	$2.56	2.20
25-25.9	2.30	2.35	2.58	2.22
26-26.9	2.36	2.37	2.60	2.24
27-27.9	2.41	2.39	2.62	2.26
28-28.9	2.46	2.41	2.64	2.28
29-29.9	2.52	2.43	2.66	2.30
30-30.9	2.57	2.45	2.68	2.32
31-31.9	2.62	2.47	2.70	2.34
32-32.9	2.68	2.49	2.72	2.36
33-33.9	....	2.51	2.74	2.38
34-34.9	....	2.53	2.76	2.40
35-35.9	....	2.55	2.78	2.42
36-36.9	....	2.57	2.80	2.44
37-37.9	....	2.59	2.82	2.46
38-38.9	....	2.61	2.84	2.48
39-39.9	....	2.63	2.86	2.50
40 and above	....	2.65	2.88	2.52

*For crude from Daboval, El Campo, and Sand Point.

†Includes Lea County, New Mexico.

Last general price change represented a 50-cent increase, effective December 6, 1947.

‡Standard Oil Co. of California.

FLAT CRUDE PRICES

Representative posted schedules per barrel.	
Kettleman Hills, California*	$2.80
Louisiana:	
Beauregard Parish	2.60
Cotton Valley (distillate)	2.85
Cotton Valley (crude)	2.70
Texas:	
East Texas	2.65
Pecos County (Yates)	2.35
Conroe	2.83
Van	2.48
Pennsylvania Grade:	
Bradford	4.25
Southwest Pennsylvania	3.82
West Virginia	3.76
Illinois Basin	2.77

*37°-37.9°.

EQUIPMENT MEN . . . in the News

Seismograph Annual Meeting on Anniversary

Party chiefs, junior party chiefs, party managers, and 10-year employes attending S.S.C. annual technical meeting.

Department heads and supervisors attending Seismograph Service Corp. annual technical meeting in Tulsa.

Seismograph Service Corp., Tulsa, held its annual meeting on the occasion of its twenty-first anniversary October 24 and 25 in Tulsa. More than 250 employes from domestic and foreign operations were in attendance. Among those attending were: R. F. Aldredge, vice president, Seismograph Service of Mexico; H. C. Bickel, vice president, Seismograph Service of Canada, and J. E. Dorris, vice president, Seismograph Service of Venezuela.

G. H. Westby, president of S.S.C., Dr. A. J. Barthelmes, and H. M. Thralls reported on the over-all scope of S.S.C.'s operations, which include more than 60 field crews throughout the world.

The first day of the meeting included a discussion on problems of internal interest, and on the second day technical and scientific papers were presented. During this meeting service pins were presented to employes. J. I. Garrette and W. O. Heap, party chiefs of the year, were presented with special awards by Westby.

Royston Laboratories New Anode Distributor

Royston Laboratories, Inc., Blawnox, Pa., manufacturers of protective coatings, have been named distributors for Dow magnesium anodes for the protection of underground and underwater structures, according to W. S. Loose, sales manager, magnesium department, The Dow Chemical Co.

Dow anodes to be distributed by Royston include the cast magnesium anodes such as Galvo-pak and Galvoslab as well as the extruded ribbon anode, Galvo-line, all of which are used in the protection of such structures as underground pipe lines, gas-distribution systems, and steel transmission towers.

Bettis to Head West Coast Division of Johnston Testers

W. F. BETTIS

W. F. (Bill) Bettis, Johnston Testers, Inc., and a member of the staff of the original M. O. Johnston Oil Field Service since 1933, has been made vice president of Johnston Testers, Inc., in charge of the West Coast division and export sales. This appointment was made following the transfer of Tommie Johnston from Los Angeles to Houston as executive vice president and assistant to W. B. Taylor, president.

Bettis started in the oil fields with Wilshire Oil Co. at Santa Fe Springs, Calif., in 1928. He joined Pacific Oil Tool, forerunner of Lane-Wells Co., as tool designer in 1931. Following his move with M. O. Johnston, Bettis developed the export sales department for the company in 1934. Ten years later he became vice president and general manager of M. O. Johnston Oil Field Export Corp. With the purchase late in 1951 of M. O. Johnston's four corporations by Johnston Testers, Inc., he retained charge of the export division and was elected a vice president of the new company.

Hughes Tool Transfers Short to Shreveport

Hughes Tool Co. has announced the transfer of Tom M. Short from Lafayette, La., to Shreveport, as Ark-La-Tex division engineer.

Short has been associated with Hughes Tool since 1938 in Oklahoma, Kansas, and South Louisiana. He received a bachelor of science degree in mechanical engineering at University of Oklahoma.

Houston Chapter of Nomads Sponsor Barbecue Meet

The October meeting of the Houston Chapter of Nomads was held at the Texaco Country Club, where 75 Nomads and guests attended a barbecue.

Barbecue and tournament chairman for this meeting was Nomad Jack A. Barnes, Trinity Portland Cement Co. Among the foreign guests present were: M. G. Erhard, International Petroleum Co., Talara, Peru, and Ing. Ivan Carvalho, Brazilian Government Oilfields, Bahia, Brazil.

Nomad Barnes, Erhard, and Carvalho.

B-J Names Representative In British West Indies

GEORGE KAYNE

The appointment of Trinidad Oilfield Service, Ltd., San Fernando, Trinidad, as agents for Oil Tool and PB Divisions, Byron Jackson Co., for the British West Indies, has recently been announced by B. A. Hilliard, general sales manager, Byron Jackson Co. The appointment was effective July 1, 1952.

George Kayne, general manager of Trinidad Oilfield Service, Ltd., recently completed a course of training at the B-J factories in Los Angeles.

United Supply Appoints Wood Store Manager

J. H. WOOD

John H. Wood has been appointed store manager of United Supply & Manufacturing Co. store in Pauls Valley, Okla., as recently revealed by H. B. Gutelius, Jr., president of the Tulsa firm.

Wood has been affiliated with United Supply since May 1950. His previous experience includes bookkeeping for Reinhart - Donovan Construction Co., Oklahoma City; parts expediting for Douglas Aircraft Co., Oklahoma City, and structural iron work for Stacy Manufacturing Co., Cleveland.

Reed Appoints Childs New Sales Manager

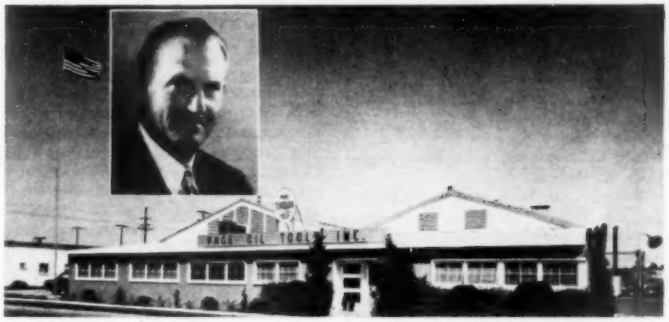
W. L. CHILDS

Reed Roller Bit Co., Houston, has appointed W. L. Childs, Jr., as sales manager of the Oil Tools Division of the company. The announcement was made by R. G. Hamaker, vice president in charge of sales.

Childs, who was graduated from University of Texas in 1939 with a degree of bachelor of science in petroleum production engineering, has been with Reed Roller Bit Co., except for a period spent in the Armed Services.

Childs was appointed manager of the company's south central sales division in Shreveport in 1948. After a brief sojourn in Calgary, Alta., where he managed the Canadian sales division, he was transferred back to Houston in August 1949 as manager of the Gulf Coast sales division. He held this position until his promotion to sales manager.

Page Oil Tool Announces New Plant Extension



Page Oil Tools Co., Inc., in keeping with an expansion program, has doubled the size of its factory, and additional office space has been added. Complete facilities for the manufacture of Page tubing anchors, oil and gas separators, tubing drains, packers, cementers, and hydraulic control equipment provide increased production capacity. According to John S. Page, president, (inset) additional field representation has also been set up to offer wider field service to the oil industry. Sales and service offices are located in Long Beach, Oklahoma City, and New York, with complete sales and service throughout the Mid-Continent and Western Canada.

Faulkner Honored at P.E.S.A. Dinner

In attendance at a special meeting of Petroleum Equipment Suppliers Association, Los Angeles, honoring David S. Faulkner, were: Ted Sutter, Baker Oil Tools, Inc.; J. A. Crawford, Youngstown Sheet & Tube Co.; E. S. Dulin, Byron Jackson Co.; Faulkner, retired vice president, National Supply Co., and F. C. Merritt, Byron Jackson Co.

David S. Faulkner, retired vice president of National Supply Co., was officially installed as director emeritus at a special dinner meeting of the Petroleum Equipment Suppliers Association, Pacific District, Los Angeles. Faulkner was presented with a scroll in recognition of his service to the industry.

Before an audience of several hundred equipment men, E. S. Dulin, president Byron Jackson Co., made the presentation to Faulkner on behalf of the association. Other old timers who spoke were J. A. Crawford, Youngstown Sheet & Tube Co., and F. C. Merritt, Byron Jackson Co. Presiding was Ted Sutter, Baker Oil Tools, Inc., in the absence of Otto Hammer, Security Engineering Co., chairman of the Pacific District P.E.S.A. board of directors.

Faulkner, widely known throughout the industry, was president of the old Union Tool Co., bought out by National Supply in 1920. In 1927 he was made vice president of National Supply and contributed materially to the growth and stature of that company.

Faulkner was a founder of P.E.S.A., a force behind the original institution of the A.P.I. standardization program, and is an honored member of A.I.M.E. He retired from National Supply Co. in January of this year.

R. H. Koehler to Head Le Roi Ad Department

R. H. KOEHLER

Richard H. Koehler has been appointed manager of Le Roi Co.'s advertising and sales promotion department, according to T. O. Liebscher, president. Koehler replaces Guy Scrivner, who has been transferred to a position in Le Roi's engine sales department.

Koehler has been advertising manager of Stearns Magnetic, Inc., since December 1948, and prior to that had extensive experience in consumer goods advertising.

Scrivner has been advertising and sales promotion manager of Le Roi since 1948 and had previous experience in Le Roi's engineering, service, and sales departments. Scrivner will represent Le Roi as sales engineer in Michigan, Ohio, Indiana, and Illinois.

Jarecki Appoints Swain Asst. General Manager

F. E. SWAIN

F. E. Swain has been named assistant general manager, Jarecki International Supply Division, H. K. Porter Co., Inc., Dallas, it has been announced by F. E. Suder, general manager. Swain will assist Suder in all operations of Jarecki International.

During his more than 10 years' experience in the oil-field-supply business Swain has served in various capacities with International Derrick & Equipment Co. at Columbus, and in the Ideco supply store division.

With the consolidation of the Jarecki and Ideco stores under H. K. Porter Co., Inc., Swain was appointed assistant to the general manager, which position he held until his present promotion.

Blaw-Knox Holds Sales Conference in Pittsburgh

Some 225 members of Blaw-Knox Co.'s sales force from all over the country assembled for a 3-day sales conference in Pittsburgh in late October. According to W. Cordes Snyder, Jr., president of the company, the purpose of the assembly was to brief the company's sales and engineering personnel on the adoption of a more aggressive business philosophy.

The first day's sessions were held at the Schenley Hotel in the civic center of Pittsburgh. Keynoter for the morning session was Dr. Samuel N. Stevens, president of Grinnell College, Grinnell, Iowa.

At luncheon the group heard Richard F. Sentner, assistant executive vice president, commercial, of United States Steel Co.

Addresses at the first day's session by officers of the company included: "Production and Sales" by Otto G. Schwenk, vice president; "Finance and Sales" by George L. Langreth, finance vice president and treasurer; "Purchasing Practices as an Aid to Sales" by John E. McWilliams, general purchasing agent; "Advertising as an Aid to Sales" by A. E. Hohman, advertising manager.

The group was also addressed by M. K. Mellott, president of the public-relations firm of M. K. Mellott Co., on the relationship of public relations to the company's general sales program.

The third day's activities were devoted to meetings of divisional groups and inspection trips to the Pittsburgh plants of the company.

United States Steel Co. Promotes Chapman, Barton

The appointment of Marcus M. Chapman as assistant general manager of sales, distribution, United States Steel Co., and James P. Barton as manager of sheet and strip sales, succeeding Chapman, has been announced by J. D. Darby, vice president and general manager of sales.

Chapman started with U. S. Steel in 1919 at the Vandergrift plant of American Sheet & Tin Plate Co., a U. S. Steel subsidiary. He spent 12 years as a salesman in St. Louis and Kansas City, and in 1936 was appointed assistant to the manager of sales in the Chicago district. He was transferred to Pittsburgh in 1939 as assistant to the manager of sheet and strip sales. Chapman was promoted to manager of sheet and strip sales in 1945.

Barton joined U. S. Steel in 1935 in American Sheet & Tin Plate Co., and following several promotions within the sheet and strip sales division of the company, he was advanced to assistant to the manager of sheet and strip sales in 1948, the position he has held until the present time.

Baash-Ross Executives Gather for Staff Meeting

Officials and directors of the Baash-Ross Tool Co. recently completed a 3-day meeting at the Odessa, Tex., plant, newest of the 17 major plants and service headquarters that Baash-Ross operates throughout the nation's oil industry. Headed by L. F. Baash, president and major stockholder, the company's representatives came from various parts of the country to hold both general sessions and group meetings on the latest Baash-Ross sales and manufacturing activities.

Shown in the group photograph are: front row, Bob Morris, assistant superintendent, West Texas Gas Division; Al Schoettler, Houston office manager; L. L. Garren, manager West Texas division; Bill Noland, superintendent, Pampa plant; W. J. Williams, general works manager; George Nordyke, manager of Olney, Ill., division; Don Moorhausen, production control manager; H. (Ink) Wotkyns, vice president in charge of Mid-Continent division, and Bill Wallace, Oklahoma City office manager.

Standing are: R. L. Le Bus, northern Mid-Continent district manager; C. E. Laws, southern Mid-Continent district manager; A. F. Brown, vice president; F. L. Tooley, executive vice president; T. A. Boyd, secretary-treasurer; G. D. Johnson, vice president; E. M. Gearke, general sales manager; L. F. Baash, president; J. L. Dickman, chief engineer; Don Bowcutt, Casper, Wyo., sales representative; H. L. Richards, industrial-relations manager; W. J. Cooper, manager Oklahoma City service and rentals; Dr. Richard Dickman, director; O. A. Brown, manager of service and rental department; Doc Eakin, manager Odessa service and rentals; Jess Moody, Odessa office manager; Ralph Hall, district manager, Casper, Wyo.; Robert Flynne, assistant controller, and J. L. Barnett, West Texas district sales manager.

K. S. Ross, export manager, who was on an extended trip through the oil areas of South America, and Lee J. Laird, assistant sales manager, who was in the New York Baash-Ross offices, were unable to attend the meeting.

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UNDISPLAYED CLASSIFIED 20c a word one issue. 10% Discount three or more consecutive issues. $4.00 minimum charge. Blind Box in our care nine words. Payable in Advance.

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$14.00 a column inch one issue . . .
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Address Classified Advertising Material: The Oil and Gas Journal, P. O. Box 1260, Tulsa 1, Okla.

EQUIPMENT FOR SALE

SALES and rentals of cable drilling and fishing tools, casing and equipment, from the Southwest's largest stock of used cable tools and oil field supplies. Degen Pipe and Supply Co., Tulsa, Oklahoma.

NOW working in South Texas area, Cardwell "Mobilhoist" double-drum workover rig powered with Waukesha gas-gasoline 6 MZR engine. 5000' Rig complete with 5000' ⅞" swab line, 1" drill line Brewster 50 ton three sheave block and hook, 7" x 5½" double telescoping 55' pole. Complete with O.C.T. packoff for 2" and 2⅛" tubing, substructure, hand tools, weight indicator, etc. Less mud pump. Price $6500.00. Box G-167, The Oil and Gas Journal, Tulsa, Oklahoma.

FOR SALE: One 36-L Bucyrus-Erie drilling machine, complete with tools. Also 1,943 ft., new 7 inch, 17 lb., H-40, range 2, seamless casing and 2,400 ft. of new 2⅜ inch 4.60 lb., range 2, J-55, seamless regular tubing. Box E-812, The Oil and Gas Journal, Tulsa, Oklahoma.

USED PIPE

50,000' 3½" OD 8.38# P.E. D.R. L.W. Used Line Pipe
15,000' 4½" OD 10.79# P.E. D.R. L.W. Used Line Pipe
4,000' 8⅝" OD 24.70# P.E. S.R. L.W. Used Line Pipe
7,000' 18" OD 70.59# P.E. S.R. E.W. & L.W. Used Line Pipe
7,000' 20" OD 65.71# P.E. S.R. E.W. & L.W. Used Line Pipe

Also Tubing & Casing for Sale

Phone or Write

SANDY SUPPLY COMPANY

Wooster, Ohio Phone 173 — Zanesville, Ohio Phone 2-8766

USED EQUIPMENT

1—Bethlehem Pumping Unit
35 HP—19000# Polish rod load
W/ ZC 503 F&M Gas Engine

2—Ideco Pumping Units
44 HP—19000# polish rod load
1—W/ 739 F&M Gas Engine
1—W/ 503 F&M Gas Engine

1—Tank Battery, 4—250 bbl. tanks
10'x20' Nt'l Treating System
2½'x10' Nat'l Separator

1—Tank Battery, 2—210 Bbl. tanks
2½'x10' Nat'l Separator

CASING—TUBING—LINE PIPE

BROWN PIPE AND MACHINERY COMPANY

1311 W. T. Waggoner Bldg.
Phone ED 9828, Ft. Worth, Texas

EQUIPMENT FOR SALE

WELL drilling equipment, new or used Spudders, rotaries, core & shot hole drills tools, pipe, bits, blocks, pump jacks, valves Everything for well drilling and service Fishing tools rented. Pressey & Son, Pueblo Colo.

1—I-R XOB 10" Compressor, 2—11" X 16" and 2—5½" X 16" Superior Compressor Cylinders. 5—16" X 20" Worthington Compressor Cylinders. Alfred B. Kern, 223 Wright Bldg., Tulsa, Oklahoma.

ONE Emsco-500 equipped with 1-year old 2505 Buda Diesel Engines, Lee C. Moore triple jackknife mast with substructure. Shaffer blowout preventer, steel mud tanks. Kelco power slips, 8,000 ft. 4½-in. drill pipe with Reed Shrink Grip tool joints. Rig is complete, in good condition, ready to run. Box G-125, The Oil and Gas Journal, Tulsa, Oklahoma.

FOR SALE

Good Used 48-L and 36-L Bucyrus-Erie Drill with or without Tools.

Beacon Supply Co.

Box 398, Pampa, Texas — Phone 3377

Gaso Duplex 4½" x 6" Power Pumps with Chrysler C-36 Engines, skid mounted, immediate delivery. Also Byron Jackson, Carter Centrifugal Units. Westinghouse 20-25-30 KW Generating Units

H. H. COFFIELD
Attn.: W. H. ORR
Phones: 132—Rockdale, Texas
AT-3427—Houston, Texas

EQUIPMENT FOR SALE

FOR SALE: 40,000 ft. #1 3½" O.D. standard plain end line $0.55 per ft. 20,000 ft. 4" O.D. flues. Rogers Pipe and Supply Company, Phone 5-8850, Tulsa, Oklahoma.

FOR SALE: Walker-Neer 32-Special new in March 52, complete with all top-to-bottom tools, new lines and 1952 G.M.C. truck W. H. Bass, phone 1376, Mt. Carmel, Illinois

Easy Joint Break-out!
ARMITE DRILL COLLAR & TOOL JOINT COMPOUND
ARMITE LABS., 6809 Broad St., Los Angeles 1, Calif.
Ball & Black Supply Co., 2871 E. Pico, L. A. 23, Calif.

FOR SALE

MODEL 1050 IDECO RIG

Powered With
Three G-M Twin Diesels

136 Ft. Lee C. Moore, Heavy, Wide-Base Mast

4½" Grade E Drill Pipe with Hard Bands Drilled Four Gulf Coast Wells.

Rig is Complete and in Good Condition.

Write Box G-166, The Oil and Gas Journal, Tulsa, Oklahoma

COPPER TELEPHONE WIRE

Oil Pipe Line Company in coils of approximately one mile. Price 25c per pound, F.O.B. 30,000 pounds #9 B & S bare copper wire. Reclaimed in good condition from Interstate De Queen, Arkansas.

J. E. Wommack

DE QUEEN TELEPHONE COMPANY — DE QUEEN, ARKANSAS

FOR SALE

Ingersoll-Rand Type 2XVG1, 75 H.P., Heavy Duty, Direct Connected 4 cycle, Gas Engine driven, Single stage Gas Compressor.

Power cylinders 2—11 in. dia. x 12 in. stroke
Compressor cylinder 1—12 in. dia. x 12 in. stroke

Complete with starting air compressor and automatic appurtenances, capable of handling 875,000 cu. ft. per day.

Purchased in September 1949, completely new, and in good operating condition. Also meters, runs, drips, heaters and other equipment necessary for small gathering system.

ROOSEVELT OIL AND REFINING CORP.

P. O. Box 271 — Mt. Pleasant, Michigan

EQUIPMENT FOR SALE

FOR SALE: 2,000 8⅝" O.D. 8 V Thread used recessed collars cleaned priced $1.50 each; 1500 12¾" O.D. Used 8 V. thread recessed cleaned priced $5.00 each, both in excellent condition, will forward samples if desired. A. A. Gilbert Pipe & Supply Co., Shreveport, La.

1 Oilwell Steam Pump, 16¼ x 7¾ x 20" 1 Gardner-Denver Steam Pump, 18 x 8 x 20". Both pumps are in excellent condition, may be seen at Makin Drilling Company Yard, Hobbs, New Mexico. MAKIN DRILLING COMPANY. Box 1628. Hobbs, New Mexico

FOR SALE: 2—Like New 50 KW Natural Gas or Gasoline Power Plants; Used Less Than Six Months, New in 1947; Under Reg. Maint. Engines—Climax "Blue Streak" Model R81, 62.5 KVA, 50 KW at .8 P.F. G.E. 127/220/3/60, 600 RPM.

GEORGE STEINER CO.
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Used Seamless BOILER TUBES

Ideal for gas, water and air lines

2¼" O.D.
3¼" O.D.
3½" O.D.
4" O.D.
5⅜" O.D.
5½" O.D.

Approximately 5 miles of each diameter available in single or double random lengths with beveled ends.

Write—Wire—Phone

SONKEN-GALAMBA CORPORATION
2nd and Riverview (X-851)
Kansas City 15, Kansas
THatcher 9243

Equipment Values!

TRACTOR-DOZER—Caterpillar D6, ser. #9U1190, wide ga., late model w/Bros hyd. straight dozer, 18" shoes, large idlers, elec. starter, generator, lights. Checked over, steam cleaned and painted. An excellent buy. FOB Louisville $6,500.00

SHOVEL—Lorain TL20, ½ yd., ser. #17521, powered by Waukesha eng.; equipped w/16'6" boom and 14'6" dipper stick. Late 1948 model, used only 10 months. FOB Paducah, Ky. $7,700.00

ENGINE-POWER UNIT—Cat Diesel D337X, ser. #22B165. This is the new 233 HP "Cat" engine with steel channel base, enclosed clutch, engine mounted controls, and safety device. Used 500 hours, rebuilt and guaranteed. FOB Paducah, Ky. $5,875.00

TRACTOR-DOZER—Caterpillar Diesel D4, ser. #5T6131, w/Southwest angle-dozer & Hyster D4N towing winch. Standard ga. tractor w/crankcase guard, front pull hook, heavy duty radiator guard. Cleaned, painted, ready to go. FOB Louisville $4,500.00

AIR COMPRESSOR—Gardner-Denver 210 cu. ft., ser. #152667, powered by Cat Diesel D318 eng., mounted on four 7.50x16 tires. Hourmeter shows 227 hours. Rebuilt and guaranteed. FOB Ashland, Ky. $6,615.00

MOTOR GRADER—Cat Diesel No. 12, ser. #9K4616, 75 HP grader w/leaning front wheels and scarifier less teeth, mounted on four 13.00x24 rear tires & two 7.50x24 front tires. Completely gone over, cleaned, painted. Priced for quick sale. FOB Louisville $6,450.00

ROY C.
WHAYNE
SUPPLY CO.
800 W. MAIN ST., LOUISVILLE, KY.

EQUIPMENT FOR SALE

OIL Field Casing, New 5½" and 7" German casing from Houston storage. Immediate delivery. P.O. Box 929, Houston, Texas.

COUPLINGS For Sale: 10,000 6⅝" OD used 8V API line pipe couplings @ $1.25 each, 10,000 8⅝" OD used 8V API line pipe couplings @ $1.50 each, 2,000 10¾" OD used 8V API line pipe couplings @ $6.00 each. F.O.B. Breckenridge, Texas. All couplings clean and in first class condition. Contact Oil Field Salvage Company, P. O. Box 812, phone 232, Breckenridge, Texas.

FOR SALE at our Okla. City Whse.: 60,000' of 4½" OD Used PE Beveled Line Pipe, 25,000' of 3½" OD Ditto 30,000' of 6" Standard PE Used Line Pipe. All Single Lengths. Cities Service Oil Co., Patridge, Bartlesville, Oklahoma

2 EA. 20,000# Steam per Hr. Hedges-Walsh-Weidner Cross Drum Water Tube Boiler, 3604 HS, built for 200# rating, 262# WP. With steel shell, supports and integral furnace, ready for loading intact. Inspection guaranteed. Perfect, $6,000 ea. FOB Car. 1 Ea. 262-319 HP Kewanee Firebox ASME, 100#, $3500. UNITED STEEL PRODUCTS COMPANY, 35-2855, 1534 Texas St., Memphis, Tenn.

FOR SALE: Two WAKU Waukesha's with Twin Disc clutches: One 145GK Waukesha, enclosed and skidded. Each with gas-butane equipment. Manufacturers Distributing Company, Great Bend, Kansas.

FOR SALE
USED REFINERY EQUIPMENT
LOCATED IN MICHIGAN

(3)—2355 Sq. Ft. Vapor Condensers, 125 PSIG.
(2)—1485 Sq. Ft. Vacuum Condensers, 125 PSIG.
(3)—720 Sq. Ft. Condensers, 125 PSIG.
(2)—258 Sq. Ft. Condensers, 125 PSIG.
(2)—440 Sq. Ft. Condensers, 75 PSIG.
(1)—470 Sq. Ft. Exchanger, 250 PSIG.
(2)—1634 Sq. Ft. Exchangers, 150 PSIG.
(1)—394 Sq. Ft. Exchanger, 125 PSIG.
(2)—275 Sq. Ft. Coolers, 125 PSIG.
(1)—819 Sq. Ft. Cooler, 60 PSIG.
(1)—550 Sq. Ft. Cooler, 75 PSIG.
(2)—225 Sq. Ft. Heaters, 125 PSIG.
(1)—Vacuum Flash Tower: Top section contains 5 trays on 27" spacing. I.D. is 9 feet. Bottom section contains 5 trays on 27" spacing. I.D. is 6 ft.
(1)—18" Manways on ½" thick shell.
(1)—5' X 17' Sulphur Tank: ⅜" Shell and Dished Heads.
(1)—4' X 12' Distillate Receiver Tank: ⅜" Shell and ½" Dished Heads.
(1)—5000 gal. Emulsifier Pressure Tank, 100 Lbs. complete with coils
Pumps—Various Capacity and Sizes.

Box G-184
THE OIL AND GAS JOURNAL
Tulsa, Oklahoma

PIPE LINE PUMPS

2—Type #97802 Byron Jackson Centrifugal Pumps, 4-Stage, 6" x 18" Impellers, 1300 GPM, 900 Ft. Head, 330# Pressure, 45,000 BPD, Mounted on Cast Iron Base for Electric Motor Drive, Good Condition. Price F.O.B. Tulsa, Oklahoma, each $850.00

2—Type #101332 Byron Jackson Centrifugal Pumps, 4-Stage, 6" x 15" Impellers, 730 GPM, 1015 Ft. Head, 375# Pressure, 250,000 BPD, Mounted on Cast Iron Base for Electric Motor Drive, Good Condition, New Spare Parts for Above Pumps. Price F.O.B. Tusa, Oklahoma, each $750.00

1—Practically New Figure #1849, 2½"-x 4" x 6" Gaso Duplex Piston Power Pump, 88 GPM at 350# Pressure, 4" Liners, Powered with 30 H.P. GE Electric Motor 3-60-440, Complete with V-Belt Drive, Mounted on Steel Skid, Unit Used to Test Valves. Price F.O.B. Tulsa, Oklahoma, each $1250.00

H. A. McCarthy
310 Thompson Bldg., Tulsa, Okla.

EQUIPMENT FOR SALE

1-90 H.P. 2 Cycle Superior direct connected compressor with high and low cylinders with intercooler ready to run. Box 546, Telephone 1080, Bartlesville, Okla.

GAS METERS FOR SALE. Westcott, Foxboro and Emco. Good condition. Geo. R. Milner, Box 124, Okmulgee, Oklahoma

OIL WELL CASING, TUBING, DRILL PIPE AND LINE PIPE. Brand New, Mill Reconditioned and A-1 Used Oil Country Tubular Goods available in any quantities required by end-users and not for resale. GAS CORPORATION, 333 N. Michigan Ave., Chicago 1, Ill.

LATE Type Portable Power Unit. 300 H. P. LeRoi Gas Engine, 8 Cy., 6¾ x 7—Model RXIV. Complete with Electric Starter and Cooling System. DC to 160 KW, 0-600 Volt Generator with Auxiliary 36KW 230 Volt Generator. We will sell engine separately, if desired. Brazos Engineering Company, 224 Raines Street, Houston, Texas. Phone: FAirfax 8367.

EMSCO Draw Works, series GA-500, complete with catheads, 2 engine compound hydromatic, & 2 pump drives. Only drilled 7 or 8 wells, now completely overhauled present condition virtually good as new. Can be inspected at Taylor Machine Shop, Glen Rock, Wyom. Price $30,000; about 50% new price. Ameera Oil Co., 139 So. Beverly Drive, Beverly Hills, California.

FIVE pumping units 2,500 to 3,000 ft. depth. Three O.C.S. pumping units 5,000 ft. depth. All in good used condition. P.O. Box 861, Oklahoma City, Okla.

3500' OF 3½" BOTTLENECK Drill Pipe. 3600' of 3½" Internal Flush External Upset Drill Pipe. All above pipe Sonoscoped 70% #2 30% #3. Also 4600' of 4" OD 14# R2 Sml Drill Pipe w/ 5¼" OD Tool Joints. Milford Giffin, Tel. 477, Hoisington, Kansas.

FOR SALE: 1—Super D Spudder, powered with 100 horse International engine. Equipped for Butane, all tools complete from 15" on down. This rig is now on location near Fruita, Colorado. Price $9000. Send all inquiries to: Mr. R. Mitchell, Room 206, Claypool Hotel, Indianapolis, Indiana

EQUIPMENT WANTED

WANTED: Oil Well Casing, Tubing, Drill Pipe and Line Pipe, new, reconditioned and A-1 Used. Give complete description, price and location. GAS CORPORATION, 333 N. Michigan Ave., Chicago, Ill.

WANTED four 125 lb. square inch WP Vertical Autoclaves, jacketed, agitated, steel, glass lined, or stainless maximum diameter of jacket 8'-0". Capacity — 2500 gallon min. to 4000 gallon max. Box G-174, The Oil and Gas Journal, Tulsa, Oklahoma

WANTED: Three engine compound for Wilson Titan drawworks. Makin Drilling Company, Box 1628, Phone 3-3141, Hobbs, New Mexico.

WILL PAY highest prices for used casing, used line pipe, abandoned leases, or other surplus lease equipment. Your idle producing equipment is worth dollars. Green Pipe & Supply Co., Box 1383, Tulsa, Oklahoma.

WANTED: Laboratory Equipment, ductility apparatus. Send full particulars to Wisconsin Oil Refining Co., Sheboygan, Wisconsin.

WANTED
TWO OIL DRILL RIGS

6,000' and 10,000'. Preferably EMSCO 800 or BREWSTER N-7. Must be in perfect condition. Location immaterial. State price, age, condition and availability.

THE NEW ENGLAND INDUSTRIES, INC.
120 WALL STREET, N.Y.C.
TEL.—WHitehall 3-1600.

HELP WANTED

WELL integrated oil company, operating in the Mid-Continent and Rocky Mountain areas, is interested in a capable and experienced geologist with sufficient geologic background and experience in exploration to assume the position of Manager of Exploration and Geological Departments. Salary open. All replies will be held in strict confidence. Box G-146, The Oil and Gas Journal, Tulsa, Oklahoma.

EXPERIENCED Seismologists and Seismic Computers by large, well established geophysical company. Give full details of education and experience in letter. Box G-176, The Oil and Gas Journal, Tulsa, Oklahoma.

WELL integrated oil company, operating for the most part in the Mid-Continent and Rocky Mountain areas, is interested in man with executive background and ability to assume position of Vice President in charge of Exploration, Production, and Land Departments. Position open due to retirement of present head involving reorganization. Marvelous opportunity for right man with sufficient qualifications. No other need apply. Salary no object. Box G-147, The Oil and Gas Journal, Tulsa, Oklahoma.

FLIGHT CREW WANTED FOR EXECUTIVE MULTI-ENGINE OPERATION IN MIDWEST AREA

FIRST PILOT—ATR, MEL ratings, must have considerable experience as first pilot on multi-engine land equipment, prefer airline trained.

CO-PILOT—Commercial, Instrument and Multi-engine land ratings.

Submit complete resume and recent photo.

Box G-177, The Oil and Gas Journal, Tulsa, Oklahoma

COLGATE-PALMOLIVE-PEET CO.

The following opportunities are now open on our engineering staff:

JR. CHEMICAL ENGINEER. To analyze and prepare process design specifications, chemical units and instrumentation. College graduate with 1 to 3 years experience desired.

JR. MECHANICAL ENGINEER. To analyze and prepare mechanical design, specifications, and equipment layout of process plants. College graduate with 1 to 3 years experience desired.

DESIGN DRAFTSMEN. To analyze and prepare equipment layout and detailed drawings from process details. This includes flow diagrams, heat and material balances, piping arrangements, etc. 7 to 12 years experience desired.

DRAFTSMAN. To prepare detailed process plant equipment and layout drawings. 3 to 7 years experience desired.

If you have experience and education in these fields send a complete resume to:

PERSONNEL DEPARTMENT
105 Hudson St., Jersey City, N. J.

TECHNICAL WRITER WANTED THE OIL AND GAS JOURNAL

Position is open on editorial staff of The Oil and Gas Journal at its Houston office. Experience necessary in exploration, drilling, oil field operations.

Young man in this position will have opportunity to grow in various divisions of large editorial department. Must have news or report gathering ability, and like to write.

Write letter to P. O. Box 1260, Tulsa, attention managing editor, including details on background, including education, and small photo. The Oil and Gas Journal, Tulsa, Oklahoma.

HELP WANTED

WANTED: Experienced contact man to represent well established oil field service company in West Texas. Prefer background of petroleum engineering or geology. Excellent opportunity. Please write brief letter giving qualifications. (Our employees know of this ad). Box G-141, The Oil and Gas Journal, Tulsa, Oklahoma.

OIL Industry Employment Service, 405 Tuloma Bldg., Tulsa, Okla. 4-5974. Tom Robinson, owner. For Technical and Trained Personnel, including LPG.

THOROUGHLY experienced top to bottom cable tool drillers Rocky Mountain experience preferred but not necessary. Bucyrus rigs. $2.00 per hour, time and half overtime, year-round work for sober trustworthy men. Telegraph or write where can contact will reply immediately. DAKOTA BASIN DRILLING CO., Hot Springs, South Dakota.

BUYER

Integrated oil company in Oklahoma has excellent opportunity for qualified applicant. Must have experience in production; also sales experience in heavy equipment would be helpful. College degree, including petroleum and mechanical engineering and some business administration. Age 28-33. All replies should contain salary required and recent photograph. Box G-165, The Oil and Gas Journal, Tulsa, Oklahoma.

REGISTERED professional engineers experienced in evaluation oil and gas properties by major oil company headquarters Tulsa. State experience and qualifications. Box 521, Tulsa, Oklahoma.

SUPERINTENDENT OF OXYGEN PLANT Graduate chemical or mechanical engineer, with minimum of three years' operating experience in oxygen plants, required for petrochemical plant of large chemical manufacturing company. Must be able to relocate in Louisiana. Please submit full resume and indicate salary desired. Box G-175, The Oil and Gas Journal, Tulsa, Oklahoma.

SEISMIC PERSONNEL needed for United States and Canada by well known and expanding contract geophysical company. Address Box E-865, The Oil and Gas Journal, Tulsa, Oklahoma.

INSTRUMENT man with refinery experience to install and maintain instruments, topping, cycloversion, thermal cracking. Box G-154, The Oil and Gas Journal, Tulsa, Oklahoma.

ACCOUNTANT with extensive production experience. Chance for advancement with growing Wichita, Kansas, company. Write full details as to age, education, experience, salary desired and date available, confidential. Box G-185, The Oil and Gas Journal, Tulsa, Oklahoma.

ASPHALT PLANT CHEMIST. Young man with Ch. E. degree desired. Minimum of three years of oil refinery experience essential. Must be capable of assuming responsibility and supervising all laboratory testing for 5,000 B.P.D. refinery located in central Southern state. Salary commensurate with training, experience and ability. Excellent opportunity for right man. Forward personal history and experience data to Box G-156, The Oil and Gas Journal, Tulsa, Oklahoma.

CHIEF PROCESS ENGINEER

Progressive, expanding refinery in Houston area desires Chemical Engineer experienced in Petroleum refining to assume duties as Chief process engineer, must be a leader and assume full responsibilities of position. Salary commensurate with experience. Address replies giving experience, salary desired, etc., to Box G-159, The Oil and Gas Journal, Tulsa, Oklahoma.

SITUATIONS WANTED

AIRLINE Transport Pilot, 45, Radio and Electronics Engineer, with 20 years executive experience. Excellent references. Contact R. Z. Glass, 4701 Linden, Bellaire, Texas.

GEOPHYSICIST - Geologist, sixteen years major company. Experienced in all phases geophysics, especially reflection seismograph over extensive areas. Ambitious to manage exploration program for small progressive company, or substantial independent. Confident of success. Houston location desired. Box G-183, The Oil and Gas Journal, Tulsa, Oklahoma.

SITUATIONS WANTED

DRILLING and Production Superintendent, 23 years varied experience. Excellent references. Box G-160, The Oil and Gas Journal, Tulsa, Oklahoma.

SUPERINTENDENT-PETROLEUM ENGINEER: 15 years experience as a geologist-petroleum engineer, last five years superintendent and manager of oil field operations desires responsible position with reliable company or independent operator. Box G-171, The Oil and Gas Journal, Tulsa, Oklahoma.

CHEMICAL ENGINEER, M.S., age 38. Texas location, desires responsible position with oil or chemical company. Formerly process engineer, refinery superintendent, independent pipeline contractor. Past 2½ years at pilot plant producing acetylene by partial combustion of methane. Present salary $8900. Box G-172, The Oil and Gas Journal, Tulsa, Oklahoma.

POSITION as superintendent, asst. supt. or still foreman. 26 years experience in refining. Six years as supt. and asst. supt. Now employed as startup operator on catalytic crackers. Box G-173, The Oil and Gas Journal, Tulsa, Oklahoma.

ACCOUNTANT-EXECUTIVE SECRETARY (female) Graduate accountant. Assistant Secretary-Treasurer of oil producing corporation, being liquidated, desires connection in Tulsa area. Fifteen years experience in petroleum production, two years public accounting. Box G-178, The Oil and Gas Journal, Tulsa, Oklahoma.

CHEMICAL Process Engineer—6 years extensive refinery and petrochemical experience plus considerable graduate work. Design and special work in distillation, reactors, ethylene recovery, low temperature refrigeration, expansion studies. Box G-179, The Oil and Gas Journal, Tulsa, Okla.

MANUFACTURERS AGENT in Permian Basin area will take on additional lines to represent. Extensive contacts and excellent relations in drilling and producing industry. Travel the area continually. Engineering graduate. Box G-180, The Oil and Gas Journal, Tulsa, Okla.

GEOLOGIST, A.B., M.S., eastern university. Desires position as a subsurface geologist which would utilize background in geophysical seismic interpretation. Resume available on request. Box G-182, The Oil and Gas Journal, Tulsa, Oklahoma.

ASSISTANT REFINERY SUPERINTENDENT desires to relocate. 6 years in present position of responsibility for both process and mechanical phases of all refinery operations. Experienced in operation of fluid catalytic cracking units. Chemical engineering graduate, 9 years experience in process development, process design and technical service work for well-known engineering and development organization. Box E-945, The Oil and Gas Journal, Tulsa, Oklahoma.

OIL AND GAS Executive, 20 years experience, desires locate Denver, Colorado, area. Adequately qualified all phases petroleum except field work. Box G-161, The Oil and Gas Journal, Tulsa, Oklahoma.

PURCHASING-Materials-Sales-Office mgt., 18 years experience petroleum and industrial equipment with large oilfield supply company consider any location or foreign. Age 39. Box G-168, The Oil and Gas Journal, Tulsa, Oklahoma.

EXPERIENCED Geologist, age 36, Masters degree, desires to relocate with small active independent preferably in Rocky Mountains or Texas. Seven years diversified experience in geology and well engineering in Southwest Texas, Mississippi, Louisiana and Alabama. Also experienced commercial pilot. Presently employed by large independent. Box G-169, The Oil and Gas Journal, Tulsa, Oklahoma.

EXPERIENCED in land and contact work, desires connection with oil or drilling company, or selling in related fields. Free to locate anywhere. T. H. Kerlin, 200 Monticello, Odessa, Texas. Phone 7-5608.

CONSULTING ENGINEER. Available for fee or retainer representation in Rocky Mountains, Permian Basin, and Kansas. Evaluations and Supervision of Royalty or Operating Interests. Geological Reports and Deal Negotiations. References. Box E-968 The Oil and Gas Journal, Tulsa, Oklahoma.

SITUATIONS WANTED

ATTENTION: Well established oil well drilling contractor desires to manage and supervise: Individuals', groups', small or medium-sized oil companies' drilling, production and operating problems in Central and Western Texas, and New Mexico Personal interview by appointment is desired. Makin Drilling Company, Box No 1628. Ph. No. 3-3141, Hobbs, New Mexico

WANTED

WISH to obtain at reasonable price second-hand copies of any issue of A.P.I.'s Drilling and Production Practice prior to 1947, except 1936. Ing. Mariano Amico Via Dei Valeri, 1 Rome, Italy.

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WILLISTON BASIN ROYALTIES
Dealers in Montana royalties since 1921, we now specialize in royalties under major company leases in the Montana portion of the Williston Basin. For information on our method of operation, write LANDOWNERS ROYALTIES COMPANY Box 1225 Great Falls, Montana

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WE will buy producing or non-producing oil royalties. Standard Security Company, 111 Broadway, New York 6, N. Y.

LEASE AND DRILLING BLOCKS

FOR SALE: Approximately 300 bbl. production per day, with a potential of several times as much. It has a dozen different pays, favorable for flooding. Also drilling, cleaning, and servicing machines, trucks and tools. Must be a bonafide company, no broker. Major Company preferred. Box G-158, The Oil and Gas Journal, Tulsa, Oklahoma.

WILL pay cash instantly for leases (large blocks), royalties, mineral deeds, production. Write fully—P. O. Box 2153, Denver, Colorado.

ACREAGE: New South Dakota wildcat, good geology, title work completed, portion landowner royalty for sale. Commence first test about November 1. For full details, write Box 822, Watertown, South Dakota

SEE A. L. BOWLES, Ada, Oklahoma, for attractive drilling deals.

ACREAGE FOR SALE: Nebraska Salina Basin Test. Drilling soon. Offset $25., ½ mile $15., balance $5. per acre. Excellent Geology. Write or call J. K. Walker, W & M Oil Co., 116 So. 15th, Lincoln, Nebraska.

WE invite inquiries from persons interested in Oil and Gas Leases and Drilling Block, also Mining Deals in Western Colorado. W. C. Catt, Ridgeway, Colorado.

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Amarillo, Texas

DALLAM COUNTY, TEXAS

8000 acres wildcat solid block NEW 10 year commercial leases $1.25 bonus $1.00 rental. Major Companies now leasing in this County.

Combest Royalty Company
Amarillo, Texas

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Producing and Nonproducing
Bought and Sold—Any Area
Inquiries Invited

B. D. BUCKLEY
6635 Delmar Ave., St. Louis 5, Mo

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CORPUS CHRISTI, TEXAS, office space for lease. Highly desirable 945 sq. ft., air-conditioned, 4-rooms in down building in which oil companies are located. J. S. Miller, 801 City National Bank Bldg., Phone Central 7471, Houston, Texas.

GEOLOGIST will exchange services for downtown, private office, Houston, Texas. Box G-181, The Oil and Gas Journal, Tulsa, Oklahoma.

BUSINESS OPPORTUNITIES

OIL CO. FOR SALE, a Colo. Corp. over one year old, capitalized at 50,000 shares no par stock. No stock sold or ever offered to the public. Assets over 15,000 acres, leases, and royalties in D-J Basin. Income about $2,000 per month at present. Other wells drilling proven lease. P. O. Box 115, Brush, Colo., or Phone 345.

REWARD OFFERED

STOLEN!!! New christmas tree valve from Central Pennsylvania. 10,000# test Serial No. 51-52-10-1044. Manufactured by Oil Center Tool Company. $500.00 reward information. Box G-124, The Oil and Gas Journal, Tulsa, Oklahoma

BUILDING SPACE

BUILDING FOR LEASE, Midland, Texas, will construct office building for long term lease. On Highway 80, excellent parking. Floyd Young, Stamford, Texas.

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Central Area

(Continued from page 473)

Q-22, dry, TD 2,661 ft.

George & Wrather 1 Hart, SW NE SW NE 2-Q-23, dry, TD 2,552 ft.

Iglehart Drilling Co. 1 Trigg, S½ NE SW SW 18-P-22, dry, TD 2,700 ft.

Hopkins County: Lafitte Co. 1 C. C. Milk Co., E½ SE NW SE 16-M-26, dry, TD 3,240 ft.

Union County: B. M. Heath 1 Proctor, NW NW NE SW 29-O-21, dry, TD 2,736 ft.

Webster County: Delta Drilling Co. 1 Tapp, S½ NE SW NW 22-N-23, dry, TD 2,693 ft.

MICHIGAN WILDCAT FAILURES

Arenac County, Lincoln Township: Frank E. Roush 1 Kopaczewski, SE NE SE 4-18n-4e, Dundee 2,713 ft., dry, TD 2,950 ft.

Oceana County: Weare Township: Ford Oil Co. 1 State-Weare, SE SW NW 13-16n-17w, Dundee 2,208 ft., dry, TD 2,217 ft.

Leavitt Township: C. W. Collin 1 Sippy, NW NW NW 23-15n-15w, Dundee 2,560 ft., dry, TD 2,862 ft.

ADVERTISERS IN THIS ISSUE

Abrams Aerial Survey Corp. 332
Acme Fishing Tool Co. 458
Acme Protection Equipment Company 463
Aeroquip Corporation 156
Aetna Ball and Roller Bearing Company 98
Air Reduction Magnolia Company 49
Aldrich Pump Co., The 117
Allis-Chalmers Mfg. Co. 39, 59
Allis-Chalmers Mfg. Co. (Tractor Division) 102
Allen Foundry & Machine Works 318
Aluminum Co. of America 72, 379
American Air Filter Co., Inc. 133
American Bosch Corporation 93
American Cable Division of American Chain & Cable Co., Inc. Inside Back Cover
American Car and Foundry Company 145
American Cyanamid Company 100
American Hoist and Derrick Company 450
American Iron & Machine Works Co. 385
American-LaFrance-Foamite Corp. 105
American Meter Company 176
American Optical Company 27
American Pipe Bending Machine Co., Inc. 435
American Recording Chart Co. 342
Ampco Metal, Inc. 168, 169
Anchor Coupling Co., Inc. 121
Anderson Brothers Corporation 439
Anderson Co., V. D. 433
Aneslie Company 462
Anglo Iranian Oil Company, Limited 418
Armour Chemical Division, Armour and Company 221
Armstrong Bros. Tool Co. 440
Armstrong Machine Works 178, 179
Atlas Chain & Mfg. Co. 57
Atlas Pipe, Inc. 441
Attapulgus Clay Company 200
Axelson Manufacturing Company 60, 113

Baash-Ross Tool Company 351
Babcock & Wilcox Tube Company, The 327
Baker Oil Tools, Inc. 224
Bank of Toronto, The 464
Baroid Sales Division, National Lead Company 69
Barton Instrument Corporation 460
Bell Rubber Company 430
Bendix Aviation Corporation 134, 135, 211
Bethlehem Supply Co. 8
Black, Sivalls & Bryson, Inc. 202, 203, 212
Blaw-Knox Construction Company 30
Bonney Forge & Tool Works 50
Bovaird Supply Co., The 34
Bristol Company, The 136
Brown Fintube Co., The 154
Buchanan Drilling Company, Al 325
Bucyrus-Erie Co. 10
Buffalo Forge Company 213
Burden Construction Corporation, O. R. 431
Butler Manufacturing Co. 205
Byron Jackson Co. 140

Cameron Iron Works, Inc. Front Cover
Canadian Bank of Commerce, The 218
Carbide and Carbon Chemicals Company, A Division of Union Carbide and Carbon Corporation 86
Carpenter Steel Company, The 183
Catawissa Valve & Fittings Co. 459
Chapman Valve Mfg. Co., The 74
Chase Brass & Copper Co. 92
Chemical Construction Corporation 64
Chevrolet Motor Div., General Motors Corp. 137
Chicago Bridge & Iron Company 271
Chiksan Company 196
Christensen Diamond Products Co. 85
Chrysler Corporation, Industrial Engine Division 73
Cities Service Oil Co. 395
Clark Bros. Co., Division of Dresser Operations, Inc. 40, 41
Classified Advertising 480, 481, 482, 483, 484
Cleveland Trencher Company, The 108
Columbian Steel Tank Co. 63
Construction Machinery Co's 338
Continental Motors Corp. 175
Cooper-Bessemer Corp., The 282, 283
C-O-Two Fire Equipment Company 22
Crose Manufacturing Co., Inc., M. J. 426
Crutcher-Rolfs-Cummings 294
Cutler-Hammer, Inc. 84

Darling Valve and Mfg. Co. 83
Davis Regulator Co. 379
Davison Chemical Corp., The 124, 125
Day Co., S. D. 440
Dean Brothers Pumps, Inc. 379
Dean Hill Pump Company 190
De Havilland Aircraft of Canada, Ltd., The 339
De Laval Steam Turbine Co. 94
Delta Engineering Sales Co. 408

Detroit Diesel Engine Division, General Motors Corp. 193
Diamond Power Specialty Corp. 322
Dollinger Corporation 24
Dominion Bridge Company, Limited 181
Dowell Incorporated 374
Dresser Manufacturing Division 142
Drew & Co., Inc., E. F. 26
Drilling and Exploration Company, Inc. 454
Drilling & Service, Inc. 455
Duff-Norton Mfg. Co. 320
du Pont 16, 170

Eagle-Picher Sales Company 340
Eaton Manufacturing Company, Axle Div. 139
Edward Valves, Inc. 20
Electric Auto-Lite Co., The 438
Elliott Company 138
Empire Trust Company 470
Ensign Carburetor Company 68
Erie Bolt & Nut Co. 299
Equivalent Valves Company 445
Ethyl Corporation 11, 12

Evinrude Motors 184
Fairbanks, Morse & Co. 2
Farrel-Birmingham Co., Inc. 80
Federated Metals Division American Smelting and Refining Company 470
Filtrol Corporation 17
First National Bank in Dallas 116
First National Bank of Shreveport, The 467
Fisher Research Lab., Inc. 450
Flexitallic Gasket Company 284
Flint Steel Corporation 445
Fluor Corporation, Ltd., The 358, 359
Ford Motor Company 395
Foster Company, L. B. 440
Foster Engineering Company 215
Foster Wheeler Corp. 6
Four Wheel Drive Auto Co., The 91
Foxboro Company, The 298
Frontier Chemical Company 447
Fuller Company 152

Gardner-Denver Company 96
Garlock Packing Company, The 157
Gaso Pump & Burner Mfg. Co. 109
General American Transportation Corporation 222, 366
General Tire & Rubber Co., The 55
Geolograph Company, Inc., The 467
Globe Oil Tools Company 449
Globe Steel Tubes Co. 118
Gordon Co., Claud S. 424
Gould's Pumps, Inc. 347
Grancell, I. H. 448
Graver Construction Co. 195
Grinnell Company, Inc. 370
Griscom-Russell Co., The 45
Grove Regulator Co. 402
Guiberson Corporation 9

Haering & Co., Inc., D. W. 367
Halliburton Oil Well Cementing Co. 21
Harrisburg Steel Corporation 422
Hawthorne, Inc., Herb J. 486
Hercules Tool Company 216
Hill, Hubbell and Company, Division of General Paint Corporation 128
Homestead Valve Manufacturing Co. 90
Hough Co., The Frank G. 78
Hudson Engineering Corporation 334
Huey & Co., S. E. 440
Hughes Tool Co. 305 through 316, Back Cover
Hy-Test Safety Shoes Division of International Shoe Company 35

Independent Exploration Co. 54
Inferno Co., The 448, 463
Ingersoll-Rand 31
Insley Manufacturing Corporation 434
International Harvester Co. 287
International Nickel Company, Inc., The 58

Jenkins Bros. 107
Jensen Brothers Mfg. Co. 451
Jerguson Gage & Valve Co. 445
Johnston & Jennings Co., The, Division of Pettibone Mulliken Corp. 160
Jones & Laughlin Supply Co. 23
Jones Company, The S. M. 38

Kelley Company, Ben F. 469
Kemp Mfg. Co., The C. M. 388
Kidde & Company, Inc., Walter 206
Kinzbach Tool Co., Inc. 451
Klemp Metal Grating Corporation 14
Kold-Hold Mfg. Co. 302
Kolor-Kut Products Co. 468
Koppers Company, Inc. 198

Ladish Co. 333
Landis Machine Co., The 7
Lane-Wells Company 95, 210
Larkin Packer Company, Inc. 214
Layne & Bowler, Inc. 183
Le Roi Company 276, 277
Leschen & Sons Rope Co., A. 219
Levingston Shipbuilding Co. 399
Linde Air Products Company, A Division of Union Carbide and Carbon Corp. 120
Link Belt Company 5
Lonergan Co., J. E. 437
Lufkin Foundry & Machine Co. 110
Lummus Co., The 112
Lunkenheimer Co., The 65
Mack Trucks 91

Macwhyte Co. 3
Magnaflux Corporation 143
Manhattan Rubber Division, Raybestos-Manhattan, Inc. 44
Manning Maxwell & Moore, Inc. 140
Manzel 356
Marlow Pumps 300
Marsh Instrument Co. 147
Martin & Company, Chas. 204
Mason-Neilan Regulator Co. 70, 71
Mathieson Chemical Corporation 48
McCord Corporation 374
McCullough Tool Company 420
McKee & Co., Arthur G. 131
Mercoid Corp., The 377
Metal Goods Corporation 62
Middle West Coating & Supply 433
Midwest Piping & Supply Co., Inc. 97
Minneapolis-Honeywell Regulator Co., Industrial Division 66, 67
Minneapolis-Moline 119
Moore Company, The 378
Moore Corporation, Lee C. 390
Morse Chain Company 199
Motorola, Inc. 48
Mundet Cork Corporation 368
Murdock Tank & Mfg. Co. 458
Mutual Chemical Company of America 384

Nash Engineering Co. 89
Natasco Company 410
National Airoil Burner Co., The 13
National Aluminate Corp. 272
National Bank of Tulsa 15
National Geophysical Company, Inc. 452
National Supply Co., The 103, 104, 105, 106
National Tube Company 76
Naylor Pipe Company 428
Nordberg Mfg. Co. 468
Nordstrom Valve Division, Rockwell Manufacturing Company 126
Norris Brothers, Inc. 437
North American Car Corporation 162

Oakite Products, Inc. 347
Ohio Injector Company 10
Oil Center Tool Co. 389
Oil Equipment Mfg. Co., Inc. 341
Oil Well Mfg. Corp. 465
Okadee Company 429
Outboard Marine & Manufacturing Co. 184
Owens-Corning Fiberglas Corp. 151
Owens-Illinois Glass Co., Kaylo Division 62

Pacific Gear & Tool Works 303
Pacific Pumps, Inc. 387
Pacific Valves, Inc. 192
Page Fence Association 216
Paris Distributor, Inc., Henry H. 417
Patent Chemicals, Inc. 166
Patent Scaffolding Co., Inc., The 447
Peerless Boiler & Engineering Co. 435
Peerless Pump Division of Food Machinery & Chemical Corporation 67
Pelton Water Wheel Co. 363
Penberthy Injector Co. 217
Perrault Brothers 439, 458
Petro-Chem Development Co., Inc. 369
Petroleum Distributing Co. 300
Petroleum Equipment Suppliers Assn. 191
Petroleum Rectifying Company 159
Philadelphia Gear Works, Inc. 188
Phillips Petroleum Company, Perco Division 444
Phoenix Manufacturing Company 472
Pinnacle Orchards 463
Pioneer Rubber Mills 208
Pipelife, Inc. 401
Pipeline Cleaners Co. 437
Pittsburgh Corning Corporation 209
Pittsburgh Steel Company 146
Porocel Corporation 200
Posey Iron Works, Inc. 52
Powell Co., The Wm. 47
Procon Incorporated 323
Pure Oil Company, The 144
Pyrene Manufacturing Company 304

Quincy Compressor Co. 348

R-S Products Corporation 127
Rasmussen Mfg. Co. 435
Raybestos-Manhattan, Inc., Manhattan Rubber Division 44
Raybestos-Manhattan, Inc., Packing Div. 130
Raymond Concrete Pile Co. 171
Lead Standard Corporation 466
Rector Well Equipment Co., Inc. 177, 450
Reed Roller Bit Company 398
Refinery Engineering Co., The 486
Reilly Tar & Chemical Corp. 349
Republic Flow Meters Co. 51
Republic Steel Corporation 79
Republic Supply Company 393
Research Vacuum Supply Company 447
Ridge Tool Company, The 330
Robbins & Myers, Inc. 326
Rockford Clutch Division of Borg-Warner Company 355
Rockwell Manufacturing Company Inside Front Cover
Rolo Manufacturing Co. 469
Rosson-Richards Company, The 427
Royal Bank of Canada, The 194
Rust-Oleum Corporation 19

S & R Tool and Supply Co. 473
SKF Industries, Inc. 443
Sarco Company, Inc. 101
Sawyer & Sons Co., The H. M. 471
Sawyer-Jensen-Ross Co. 438
Schlumberger Well Surveying Corp. 207
Schutte and Koerting Company 77
Scott-Rice Co. 471
Security Engineering Co., Inc. 288
Seismic Explorations, Inc. 278
Seismograph Service Corp. 280
Shamrock Hotel, The 458
Sherman Products, Inc. 350
Skelly Oil Company 197
Skinner Company, M. B. 75
Smith Corporation, A. O. 123, 343
Smith Corporation, A. O., Meter Division 180
Snap-On Tools Corporation 301
South Texas National Bank 324
Southern Pipe & Casing Co. 432
Spang & Co. 354
Sperry-Sun Well Surveying Co. 161
Spicer Mfg. Div. of Dana Corp. 61
Standard Oil Development Company 472
Standco Brake Lining Co. 450
Steel Forgings, Inc. 440
Strom Steel Ball Co. 431
Sun Shipbuilding & Dry Dock Company 122
Superior Combustion Industries, Inc. 132
Superior Plastics, Inc. 472

Tapecoat Company, The 430
Taylor Instruments Companies 186, 187
Taylor Woodrow (Building Exports), Ltd. 111
Technical Oil Tool Corp., Ltd. 456
Telematic Corporation 467
Tennessee - Eastman Company, Division of Eastman Kodak Company 172
Thermoid Company 374, 375
Thew Shovel Company 149
Thomas Flexible Coupling Co. 353
Thompson Tank & Manufacturing Co., Inc. 451
Timken Roller Bearing Company 153
Toledo Pipe Threading Machine Co. 150
Torrington Company, The 155
Trackson Company 56
Tretolite Company 162
Trimount Instrument Co. 435
Troatel Packings, Ltd. Albert 392
Tube Turns, Inc. 173, 174
Tulsa Engineering Sales Company 440

Union Carbide and Carbon Corporation, Carbide and Carbon Chemicals Company 86
The Linde Air Products Company 120
United States Steel Company 28, 29
Universal Oil Products Co. 404, 405
U. S. Electrical Motors, Inc. 457
U. S. Steel Corp. Subsidiaries 4, 28, 29

Victaulic Co. of America 220
Victor Equipment Company 335
Vogt Machine Co., Henry 25
Voss Co., Inc., J. H. H. 431

Wagner Electric Corporation 129
Walker Co., W. L. 429
Wallace & Tiernan Products, Inc. 424
Warner Electric Brake & Clutch Company 36, 37
Warner Lewis Company 446
Waterman Machine & Manufacturing Co. 437
Watson-Stillman 291
Waukesha Motor Company 115
Waukesha Sales & Service, Inc. 114
Web Wilson Oil Tools 463
Welex Jet Services, Inc. 226
Weil Equipment Mfg. Corp. 167
Western Gear Works 303
Western Insulated Wire Co. 470
Western Pipe Line Constructors, Inc. 383
Westinghouse Electric Corp. 32, 33, 42, 43
Wheatland Tube Company 158
Wheeling Machine Products Co. 426
Wickes Boiler Co., The 336
Wickwire Spencer Steel Division, Colorado Fuel and Iron Corp. 53, 189
Wico Electric Company 382
Williams & Co., J. H. 319
Williams Brothers 437
Williamson, Inc., T. D. 436
Wilson Supply Co. 98, 99
Winslow Engineering Co. 461
Wisconsin Motor Corporation 331
Witte Engine Works, Oil Well Supply Division United States Steel Company 4
W-K-M Company 164, 165
Wood's Sons Co., T. B. 446

Yarnall-Waring Co. 201
Young Radiator Company 141

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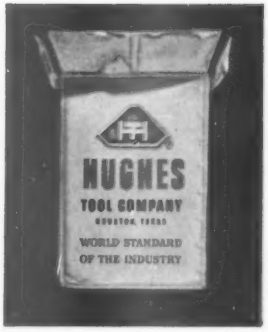

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